3. AFFECTED ENVIRONMENT

Chapter 3 of this EIS describes the existing environment in and around Oak Ridge National Laboratory (ORNL) and the Oak Ridge Reservation (ORR), which would be affected by the construction, operation, and D&D of the proposed TRU Waste Treatment Facility. ORNL is one of three major DOE facilities located within the ORR. Site-specific information for the area surrounding the proposed facility site and the adjacent Melton Valley Storage Tanks at ORNL is also included. Current, pertinent information is provided for the regions influenced in the various resource areas, and the supporting references are cited.

3.1 LAND USE

This section describes the past, current, and planned land uses on and around the proposed TRU Waste Treatment Facility site, which would be located within the boundaries of ORNL and the ORR. The ORR contains approximately 140 square miles of federally owned land in Anderson and Roane Counties of East Tennessee. The area includes forests, public use areas, and operational areas. The facility is located within the city limits of Oak Ridge, Tennessee, and the surrounding lands are predominantly rural with residences, small farms, forests, and cattle pastures. This section includes descriptions of environmentally sensitive land areas on and around the ORR that are set aside for public use, environmental protection, or research. These sensitive land areas include parks, natural areas, environmental education centers, and public recreation areas.

3.1.1 Past Land Use

The land surrounding the ORR was predominantly forested wilderness prior to the 18th century. During the late 18th and early 19th centuries, the area was settled by emigrants who established three major uses of the land, including forestry, agriculture, and residential. Gradually, commercial, mining, transportation, waterways, and industrial land uses developed. The land that composes the ORR was purchased from private landowners by the United States Government in 1942. The predominant land uses at that time were forestry, agriculture, and residential. Government activities during World War II changed the overall pattern of land use on the ORR to industrial with the establishment of the X-10 Plant (ORNL), the Y-12 Plant (Y-12), the K-25 Site [now known as the East Tennessee Technology Park (ETTP)], and various support facilities. With the exception of some agriculture-related research activities in later years, agricultural use of the land on the ORR nearly disappeared, and the land was allowed to revert to an increasingly natural forested state after its purchase by the government. Residential land use ended over most of the ORR with the exception of the northeastern corner, which housed government workers. Residential and commercial land uses increased rapidly on the north side of the reservation, and in the late 1950s this area was separated from the ORR and incorporated as the City of Oak Ridge. The current land use pattern on the ORR and at ORNL gradually evolved between 1942 and the present day (DOE 1999a).

3.1.2 Current Land Use

The current uses of land in the vicinity of the ORR are forestry, agriculture, residential, commercial, industrial, mining, transportation, waterways, recreation, and several other uses. The largest use is commercial forestry, followed in order by agriculture, other uses, residential, waterways, and transportation. The remaining uses are quite small, each accounting for less than 3,000 ha

(7,410 acres) of land. The closest urban center to the reservation is the City of Oak Ridge. The predominant land use in most urban areas is residential (MMES 1994).

DOE classifies land use on the ORR according to five primary categories: Institutional/Research, Industrial, Mixed Industrial, Institutional/Environmental Laboratory, and Mixed Research/Future Initiatives. The Institutional/Research category applies to land occupied by the central research facilities at ORNL. Land in the Industrial category includes the Y-12 Plant, which is used for defense support, manufacturing, and storage. The Mixed/Industrial category includes the ETTP, which is used for environmental management and reindustrialization of DOE land by private sector businesses. The Oak Ridge Institute for Science and Education, operated by Oak Ridge Associated Universities, provides training and research support to DOE and uses the land within the boundaries of the Institutional/Environmental Laboratory category. The Mixed Research/Future Initiatives category applies to land currently used, or available for use, in field research, and land reserved for future DOE initiatives, including new research facilities.

The proposed TRU Waste Treatment Facility site is a small 2- to 2.8-ha (5- to 7-acre), forested area almost immediately west of the Melton Valley Storage Tanks and approximately 2 km (1.25 miles) east of Tennessee State Route 95. The Melton Valley Storage Tanks are active waste storage tanks, which store legacy TRU sludge waste and its associated remote-handled low-level supernate. The area east of the proposed facility site is industrial and contains the Melton Valley Storage Tanks, associated waste bunkers, and Melton Valley Storage Tanks–Capacity Increase Project tanks. Just west of the proposed TRU Waste Treatment Facility site, the Old Melton Valley Road (High Flux Isotope Reactor access road) was upgraded. This road would be the main road running to the proposed waste treatment facility site. The proposed site for the waste treatment facility does not contain prime or unique farmland.

3.1.3 Planned Land Use

The Spallation Neutron Source is a national research project being developed as a cooperative effort of the national laboratories. The Spallation Neutron Source will be located at ORNL 4 km (2.5 miles) from the proposed TRU Waste Treatment Facility. A CERCLA waste disposal facility is also planned for construction at the Y-12 Plant and would be located in Bear Creek Valley, approximately 6 km (3.7 miles) from the proposed TRU Waste Treatment Facility. These planned projects have already undergone an environmental review as discussed in the "Cumulative Impacts" section of DOE 1999a, and a Record of Decision has been issued for the disposal site.

3.1.4 Parks, Preserves, and Recreational Resources

The University of Tennessee Arboretum is located approximately 0.4 km (0.25 mile) east of the ORR. This facility contains 101 ha (250 acres) of land and functions as a living botanical education center for the general public. Several trails with botanical themes run throughout the arboretum and are open to the public for hiking. The University of Tennessee also operates a forest experiment station on 810 ha (2,000 acres) of land adjacent to the arboretum (LMES 1996). This area is not open to the public.

Large portions of the ORR are devoted to nature preservation and biological research. About 8,899 ha (21,980 acres) of undeveloped and geographically fragmented areas of land at ORNL, Y-12 Plant, and ETTP comprise the Oak Ridge National Environmental Research Park. The National Environmental Research Park is used by the U.S. scientific community as an outdoor environmental science laboratory to study the current and future environmental consequences of the DOE mission in Oak Ridge (LMES 1995a). Numerous areas within the National Environmental Research Park are designated for the protection of rare species. A number of reference areas have been established to serve as examples of regional plant communities and unique biotic features (Pounds et al. 1993). A portion of the ORR is operated as the Oak Ridge Wildlife Management Area through a cooperative agreement between DOE and the Tennessee Wildlife Resources Agency (DOE-ORO 1996). This agreement was initiated in 1984 to reduce traffic accidents involving deer by opening the ORR to hunting by the public (Saylor et al. 1990).

The Clark Center Recreational Park, located on the north shore of Melton Hill Lake, occupies 36 ha (90 acres) of land within the southeast corner of the ORR. It is open to the public for swimming, picnicking, fishing, pleasure boating, and athletic activities such as softball. Management of the Freels Bend area, directly east of the Clark Center Recreational Area on the north side of Melton Hill Lake, was recently granted to the State of Tennessee by the Secretary of Energy. Several public recreation areas are located along Melton Hill Lake, which is outside the ORR but adjacent to a large portion of the ORR's southeast boundary. This body of water is a Tennessee Valley Authority (TVA) reservoir that was formed by impounding the Clinch River with Melton Hill Dam. The body of water on the downstream side of Melton Hill Dam is Watts Bar Lake, which is adjacent to the southwest boundary of the ORR. Melton Hill Dam is located approximately 4.3 km (2.7 miles) southwest of the central ORNL plant, but land used for laboratory activities extends south to the shore of Melton Hill Lake. A large TVA public recreation area is located at the Melton Hill Dam on the opposite shore from ORNL land and the ORR. This recreation area is used for pleasure boating, fishing, swimming, and picnicking. Other TVA recreational areas with similar uses are located along Melton Hill Lake upstream from the dam and ORNL, including 425 ha (1,051 acres) of recreational lands within the city limits of Oak Ridge (MMES 1994). A TVA boat ramp is located on the ORNL side of Watts Bar Lake, approximately 2.4 km (1.5 miles) downstream from Melton Hill Dam. Watts Bar Lake is used for pleasure boating, fishing, and swimming.

3.1.5 Scenic Resources

The steep, linear ridges; intervening valleys; and lakes in the vicinity of ORNL create beautiful, natural scenery. However, many parcels of rural land are used for agricultural and residential purposes so the visual field at many locations includes various combinations of houses, barns, roads, and utility features. In heavily developed areas of Oak Ridge, views are predominated by these features, along with numerous commercial structures, industrial plants, and public service buildings. Natural scenery abounds on the ORR, since much of it has been allowed to return to its natural state. However, the landscape in developed areas of the ORR, such as those in the vicinity of ORNL and the proposed TRU Waste Treatment Facility site, is a mixture of natural features with buildings, industrial facilities, roads, and utility features.

3.2 CULTURAL AND HISTORIC RESOURCES

The ORR area is rich in cultural resources, both prehistoric and historic. Preservation of these resources is mandated by Section 106 of the National Historic Preservation Act [16 U.S.C. 470(f)]. Several reconnaissance-level (walkover) surveys for cultural resources have been conducted on the ORR in the vicinity of the proposed project. These include Faulkner (1988) and DuVall (1992a, 1993b, and 1996). Based on these previously conducted investigations, it appears that the proposed TRU Waste Treatment Facility site has no known archaeological, cultural, or historical resources. In addition, no such resources are known to exist in areas immediately contiguous to the proposed site. The nearest potential site, located approximately 183 m (600 ft) southwest of the project site, is the pre-1942 homestead site known as the Jenkins Site (State of Tennessee registration number 40RE188). The pre-1942 homestead site known as the Jones Site (State of Tennessee registration number

40RE189) is located approximately 244 m (800 ft) northeast of the project site (Figure 3-1). An archaeological assessment of these two sites utilized subsurface testing to determine if artifact concentrations were present on the two sites (Faulkner 1988). The Jones Site and support structures were recommended for inclusion in the National Register of Historic Places due to the relatively intact nature of the site and its early occupation date (ca. 1820). The Jenkins Site has been severely affected by modern intrusions and was not considered eligible for inclusion in the National Register of Historic Places.

In accordance with the programmatic agreement concerning management of historical and cultural properties at the ORR among the DOE-Oak Ridge Operations Office, the Tennessee State Historic Preservation Officer, and the Advisory Council on Historic Preservation, DOE sent a letter submitted to the State Historic Preservation Officer on June 28, 1999, to address Section 106 for the TRU Waste Treatment Facility. Enclosed with the letter was a summary of the Archaeological and Historical Review for the TRU Waste Treatment Facility site prepared for the proposed action. DOE requested and received concurrence with their findings from the State Historic Preservation Officer regarding this proposed project (Appendix E).

DOE has consulted with Native American groups regarding the status of the ORR as a site of potential importance to Native Americans. While some isolated findings of arrowheads, pottery shards, and charcoal have been found in some project studies over the years, no tribe or group representing Native Americans has ever expressed interest in the ORR as a site of historical importance to Native Americans (Moore 1999). There are no known sensitive areas near the proposed project site.

3.3 ECOLOGICAL RESOURCES

This section provides descriptions of the terrestrial and aquatic resources, including threatened and endangered species, identified at the proposed TRU Waste Treatment Facility site. Basis for the following information was derived from the 1988 field surveys conducted in preparation of the previously proposed Waste Handling and Packaging Plant (Campbell et al. 1989). The field surveys included an area located southeast of the proposed TRU Waste Treatment Facility site. The southwestern boundary of the surveys slightly overlaps the southeastern most corner of the proposed site. The survey area’s northern edge came within less than 91 m (300 ft) of the proposed TRU waste facility’s northeast corner fence line. Surveys for sensitive plant and animal species were completed for the proposed site in April 1999, and a report on survey findings is included in Appendix C.

3.3.1 Terrestrial Resources

The proposed site for the TRU Waste Treatment Facility is at the northwest base of Copper Ridge and Melton Hill and includes a small portion of Copper Ridge. During the 1988 surveys, the area was noted to have been previously disturbed by homesteading prior to 1942 (Campbell et al. 1989). A thin layer of deciduous leaf litter accompanies slash, moss-covered surface debris, and small rocks on the soil surface. The soil surface is firm and gravelly, with a minimum buildup of organic matter. No caves or large rock outcrops are present in the proposed area.

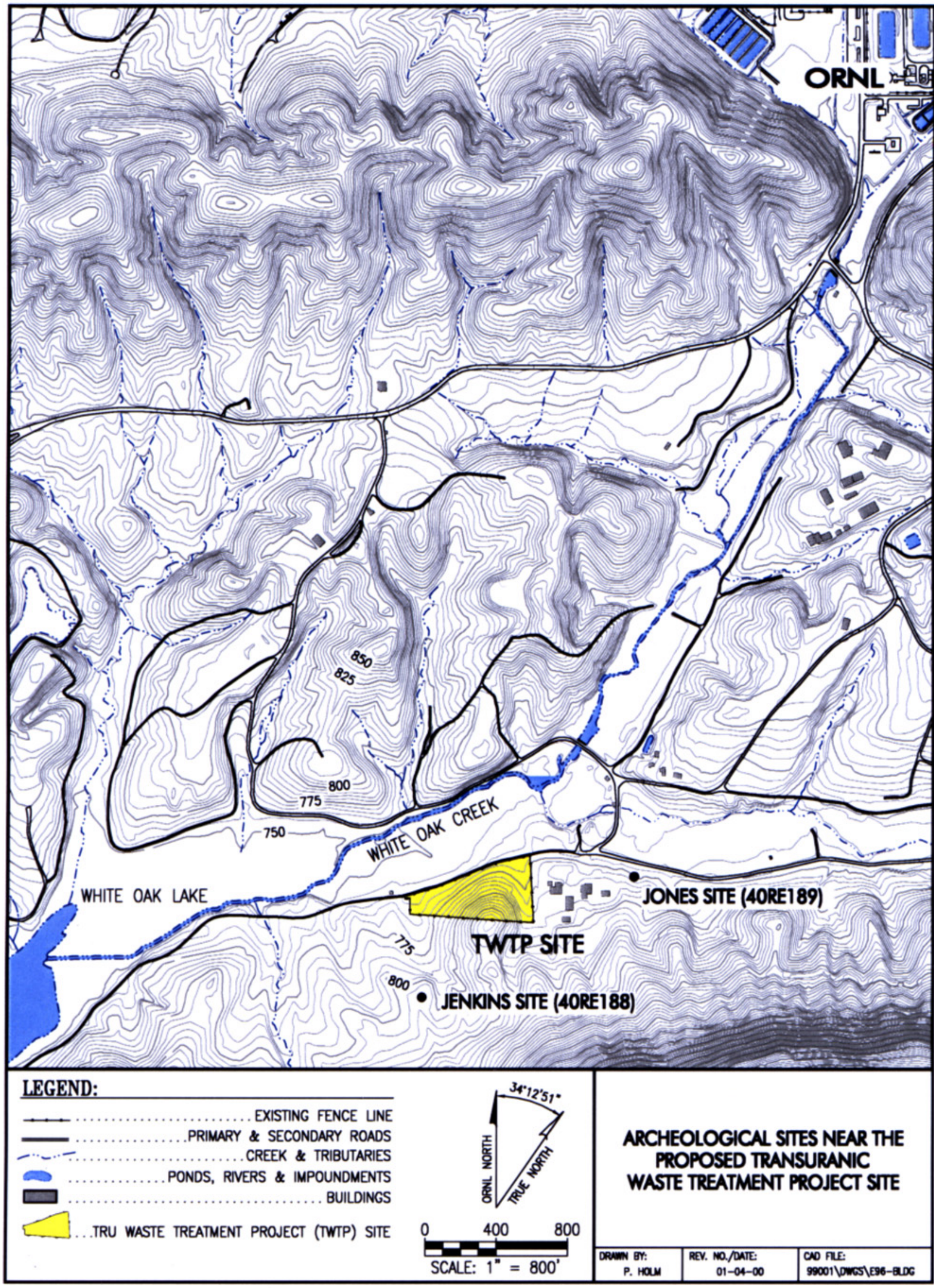


Figure 3-1. Archeological sites near the proposed TRU Waste Treatment Facility site at ORNL include the Jones Site and the Jenkins Site.

3.3.1.1 Flora

Succession on the fields of the former homesteads has produced a relatively young to mid-age open forest of pines and cedars with some hardwood species at the proposed TRU Waste Treatment Facility site. No hollow trees, living or dead, were observed in the parcel. The dominant tree species identified included shortleaf and Virginia pines in the west, fading to hardwood species such as yellow-poplar, oaks, hickories, red bud, and maples in the east (Appendix C.3). The forest on the steep slopes of Melton Hill above the proposed site is relatively undisturbed. In open areas, herbaceous species make up the ground cover of the area. Species identified in the 1999 surveys include exotic species, such as Japanese honeysuckle and Nepal grass, as well as blueberries, rusty viburnum, juneberry, and hophornbeam (Appendix C.3). A previously fenced small area is to be included in the proposed site. This area currently contains no native vegetation and consists of buildings, paved areas, and lawns.

3.3.1.2 Fauna

Because of its small size, the proposed TRU Waste Treatment Facility site possesses relatively few habitat types and supports only a fraction of the number of faunal species found within the ORR. The site's vertebrate fauna consists of species common to the second-growth, mixed hardwood-pine forest. A few species suspected to be present are snakes (rat snake and black racer); birds (red-eyed vireo, pine warbler, scarlet tanager, wild turkey, and red-tailed hawk); rodents (white-footed mouse); and mammals (coyote, gray squirrel, flying squirrel, opossum, striped skunk, and white-tailed deer).

3.3.2 Terrestrial Threatened and Endangered Species

3.3.2.1 Flora

Surveys for sensitive plant species that are specific to the proposed TRU Waste Treatment Facility site were completed in May 1999 and were accomplished by walking the entire proposed area. No Federally-listed terrestrial plant species have been reported on the proposed site (Appendix C.3). No State-listed terrestrial plant species were observed at the proposed site during the 1999 survey. Compatible habitats for four State-listed terrestrial species that are known to occur on the ORR exist within the proposed area. These species and their preferred habitats are represented in Table 3-1. Two additional rare wetland species may occur in the site. These are discussed in Section 3.3.4.1.

Table 3-1. State-listed terrestrial plant species with compatible habitats exhibited in the proposed site

Common name	Species	Preferred habitat
Heavy sedge	*Carex gravida*	Dry woods or open areas
Pink Lady's Slipper	*Cypripedium acaule*	Pine or mixed pine-hardwood
Butternut	*Juglans cinera*	Deciduous forest
Canada Lily	*Lilium canadense*	Moist, shaded drainages

3.3.2.2 Fauna

A sensitive animal survey was completed in April 1999 and was accomplished by visual identification, trapping, and installation of artificial ground covers at the proposed TRU Waste Treatment Facility site. The only Federally-listed animal species that have been recently observed on the ORR (the gray bat, bald eagle, and peregrine falcon) are represented by migratory or transient individuals rather than by permanent residents. The Federally-endangered Indiana bat has not been identified in the area, but the ORR does fall into its geographic range. Suitable habitat for the bat at the proposed site is marginal (Appendix C.2).

Several local species are listed by the State of Tennessee as "in need of management." These species may be present in the vicinity of the proposed site based on the reasoning that the proposed TRU Waste Treatment Facility site falls within their acceptable home ranges and the proposed area contains compatible habitat for them. Species listed as "in need of management" that may occur in the proposed area are presented in Table 3-2, although none of these species was observed or captured during the 1999 survey (Appendix C.2).

Table 3-2. Tennessee State-listed "in need of management" terrestrial animal species with compatible habitats exhibited in the proposed site

Common name	Scientific name	In home range	Suitable habitat present
	Aves		
Cooper's hawk	*Accipiter cooperii*	Yes	Yes
Sharp-shinned hawk	*Accipiter striatus*	Yes	Yes
Bachman's sparrow	*Aimophila aestivalis*	Yes	Marginal
Grasshopper sparrow	*Ammodramus savannarum*	Yes	Marginal
Lark sparrow	*Chondestes grammacus*	Yes	Marginal
Vesper sparrow	*Pooecetes gramineus*	Yes	Marginal
Yellow-bellied sapsucker	*Sphyrapicus varius*	Winter only	Yes
Bewick's wren	*Thryomanes bewickii bewickii*	Yes	Marginal
	Mammals		
Star-nosed mole	*Condylura cristata parva*	Marginal	Marginal
Eastern big-eared bat	*Corynorhinus rafinesquii*	Yes	Marginal
Eastern small-footed bat	*Myotis leibii*	Yes	Marginal
Hairy-tailed mole	*Parascalops breweri*	Yes	Marginal
Southeastern shrew	*Sorex longirostris*	Yes	Yes
Southern bog lemming	*Synaptomys cooperi*	Yes	Yes
Meadow jumping mouse	*Zapus hudsonius*	Yes	Marginal
	Amphibians		
Four-toed salamander	*Hemidactylium scutatum*	Yes	Marginal
	Reptiles		
Northern coal skink	*Eumeces A. anthracinus*	Marginal	Marginal
Southern coal skink	*Eumeces anthracinus pluvialis*	Marginal	Marginal
Eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*	Yes	Yes
Northern pine snake	*Pituophis M. melanoleucus*	Yes	Marginal

3.3.3 Aquatic Resources

A thorough description of the hydrology of the White Oak Creek Watershed is found in Section 3.5. The proposed TRU Waste Treatment Facility site is located in the White Oak Creek Watershed. Surface water draining from the site would flow either into White Oak Creek, or the lower portions of the Melton Branch, a tributary to White Oak Creek. From there the surface water route would continue to White Oak Lake and on to the Clinch River. White Oak Creek, Melton Branch, and White Oak Lake receive treated and untreated process wastewater, treated sanitary sewage effluent, and reactor cooling water from ORNL facilities. A small, unnamed tributary drains into the headwaters of White Oak Lake near the proposed facility site on the northern slope of Copper Ridge. The tributary is believed to be an intermittent stream, although it is not gauged and there are no known hydrological or water quality data available (Campbell et al. 1989).

White Oak Lake is a shallow impoundment created in 1941 by the construction of White Oak Lake Dam located approximately 1 km (0.6 mile) above the confluence of White Oak Creek with the Clinch River. White Oak Lake functions as a final settling basin for waste effluents discharged to White Oak Creek, Melton Branch, and other small streams in the White Oak Creek Watershed. White Oak Lake extends 0.7 km (0.4 mile) upstream from the dam and has a surface area of about 8 ha (20 acres).

Off-site aquatic invertebrate and fish surveys in the 1980s were reported to have observed several invertebrate species, and 3, 12, and 18 fish species in the Melton Branch, White Oak Creek, and White Oak Lake, respectively (ORNL 1998). Bioaccumulation studies in sunfish and largemouth bass (*Micropterus salmoides*) to monitor mercury and polychlorinated biphenyl (PCB) contamination in White Oak Creek and White Oak Lake have been conducted since at least 1994. In 1997, mercury concentrations in redbreast sunfish (*Lepomis auritis*) from White Oak Creek (White Oak Creek kilometer 2.9) and bluegill sunfish (*L. macrochirus*) and largemouth bass from White Oak Lake were approximately five-fold higher than concentrations in fish from sampled reference streams. Concentrations in the largemouth bass were greater than those in the sunfish, which is consistent with the bass's position in the food chain. In 1997, no fish from the White Oak Creek Watershed contained mercury concentrations higher than 0.50 mg/kg. Mean PCB concentrations in sunfish from White Oak Creek kilometer 2.9 and White Oak Lake during 1997 were 0.39 ± 0.10 mg/kg and 0.69 ± 0.06 mg/kg, respectively. Reference location sunfish that were analyzed at the same time averaged <0.02 mg/kg PCB. The PCB concentrations in largemouth bass from White Oak Lake ranged from 0.43 to 3.8 mg/kg PCB. Since 1994, the PCB concentrations in sunfish and largemouth bass from White Oak Creek have remained approximately two- to three-fold higher than the concentrations reported from the early 1990s (ORNL 1998).

DOE Order 5400.5, Chapter II, sets an interim absorbed dose rate limit of 1 rad/day (0.01 Gy/day) to native aquatic organisms. ORNL demonstrated compliance with this limit for aquatic biota exposed to surface water and sediments in the White Oak Creek Watershed by calculating absorbed doses to fish, crustacea (such as crayfish), and muskrats (*Mustela erminea*) (ORNL 1998). Doses to these receptors at Melton Branch kilometer 0.2, as well as at White Oak Creek kilometer 2.6, and White Oak Lake Dam kilometer 1.0, were all significantly less than the 1 rad/day limit (Table 3-3).

Table 3-3. Doses of radionuclides to aquatic receptors at ORNL surface water locations in 1997[a,b]

	Fish		Crustacea		Muskrat	
Measurement location	**Avg. (rad/day)**	**Max. (rad/day)**	**Avg. (rad/day)**	**Max. (rad/day)**	**Avg. (rad/day)**	**Max. (rad/day)**
Melton Branch (K 0.2)	1E-03	2E-03	3E-04	6E-04	3E-03	6E-03
White Oak Creek (K 1.0)	8E-04	2E-03	3E-04	5E-04	2E-03	3E-03
White Oak Creek (K 2.6)	4E-04	7E-04	1E-04	2E-04	1E-03	2E-03
White Oak Creek (K 6.8)	7E-08	1E-07	7E-08	1E-07	1E-07	2E-07

[a]Total dose rate includes the contribution of internally deposited radionuclides, sediment exposure (derived from water concentration), and water immersion.

[b]To convert from rad/day to Gy/day, divide by 100.

K = kilometer.

ORNL = Oak Ridge National Laboratory.

Source: Adapted from ORNL 1998.

3.3.4 Aquatic Threatened and Endangered Species

3.3.4.1 Flora

Surveys for sensitive plant species that are specific to the proposed TRU Waste Treatment Facility area were completed on May 12, 1999, and were accomplished by walking the entire proposed impact area. No Federally-listed aquatic plant species were found to occur on, or adjacent to, the survey area. Two Tennessee State-listed wetland species, the purple fringeless orchid (*Platanthera peramoena*) and river bulrush (*Scirpus fluviatilis*), have been identified on the ORR and may be present in wetland areas adjacent to the proposed site. Neither of these species was identified during the 1999 field survey report for rare plants (Appendix C.3).

3.3.4.2 Fauna

According to the U.S. Fish and Wildlife Service, the pink mucket pearly mussel *(Lampsilis arbrupta,* previously known as *L. orbiculata)*, a Federally-listed endangered species in the family Unionoidae of mollusks, is known to occur near the potential project impact area (Appendix E). This species is found in medium to large rivers, with habitat characterized by moderate- to fast-flowing water 0.5 to 8.0 m deep, and substrates including silt, gravel, sand, cobble, and boulders (CMI-FWIE 1996). Although small populations of the pink mucket pearly mussel have been found in the Clinch River in Tennessee (EPA 2000), this species is highly unlikely to be present in Melton Branch or White Oak Creek near the TRU Waste Treatment Facility site because the two streams are too small to provide proper habitat. In addition, the impoundment of White Oak Creek to form White Oak Lake near the proposed facility site further reduces the likelihood of pink mucket occurrences because impoundments have adverse impacts to the species. Thus, the pink mucket pearly mussel is unlikely to be present in the affected environment for the proposed faciliyy.

No Federally-listed aquatic animal species were found to occur on or adjacent to the survey area (Appendix C.2). The only Tennessee State-listed aquatic-related species observed in 1995 near the proposed site was the osprey, which occurred at the nearby White Oak Lake. Platforms have been established on Melton Lake, and this bird has become a common nester of the Melton Valley area (Mitchell et al. 1996). Species in the surrounding area listed as "in need of management" by the State of Tennessee include the little blue heron and great egret. Both species were sighted on White Oak Lake during the 1995 ORO survey (Figure 3-2) and are considered to be uncommon migrant species to the area (Mitchell et al. 1996).

3.4 GEOLOGY AND SEISMICITY

The ORR is located in the Tennessee Section of the Valley and Ridge physiographic province (Figure 3-3). This province extends more than 1,287 km (800 miles) from northeast Alabama into central Pennsylvania. Four main features distinguish the Valley and Ridge Province: long, parallel ridges and valleys oriented from northeast to southwest; similar ridge summit elevations suggesting former erosional surfaces; major traverse streams that cut through ridges with subsequent streams forming a trellis drainage pattern parallel to the valleys; and numerous water and wind gaps through the ridges. The Tennessee section encompasses the southwestern half of the Valley and Ridge province extending from northeast Alabama into southwestern Virginia. This section of the Valley and Ridge province ranges from 40 to 113 km (25 to about 70 miles) wide. In the vicinity of the ORR, the width is approximately 80 km (50 miles). Within the ORR, the principal valley and ridge landforms include, from southeast to northwest, Copper Ridge, Melton Valley (containing the proposed TRU Waste

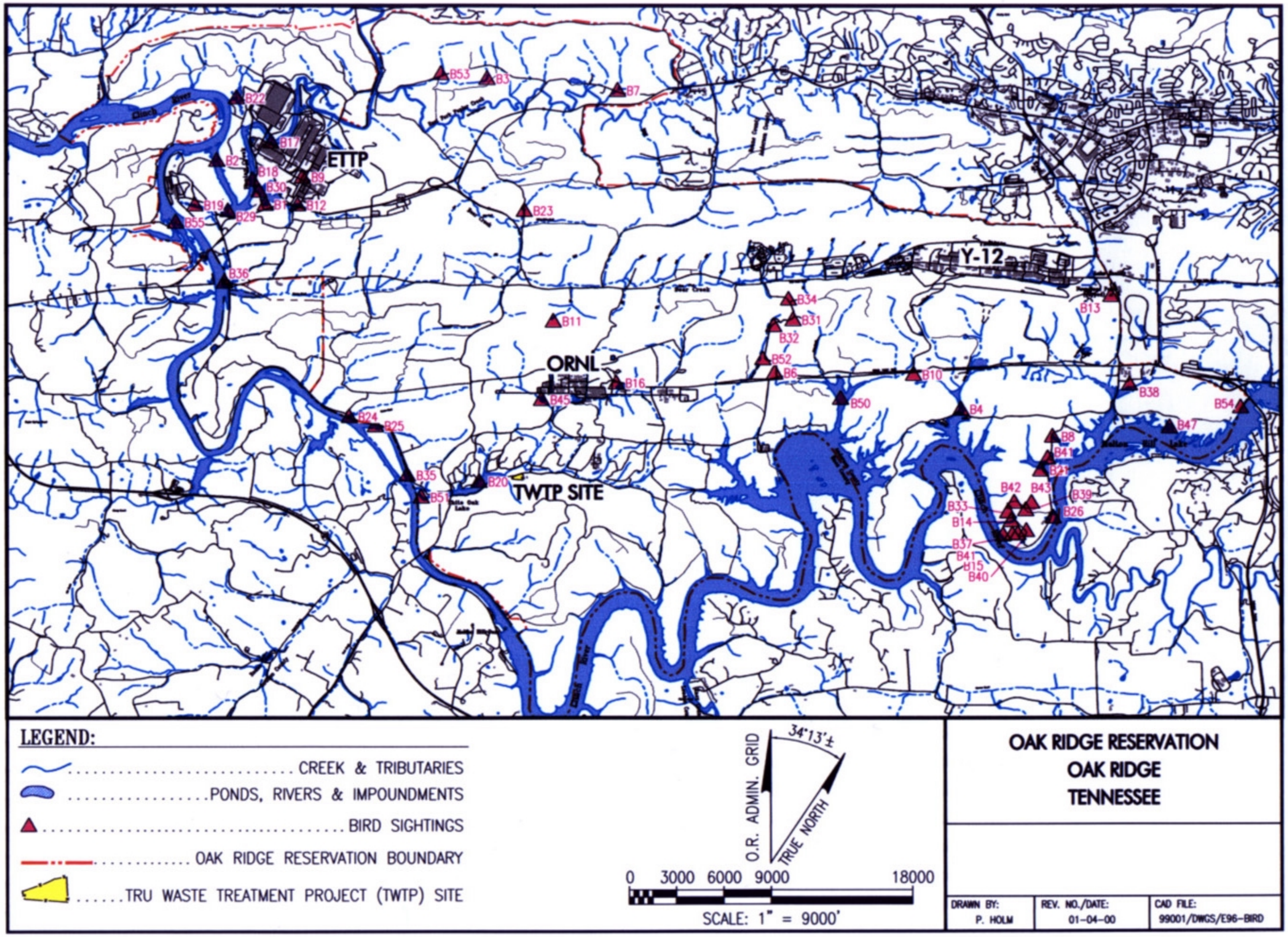


Figure 3-2. Locations of sightings of protected bird species on the ORR – 1995 survey.

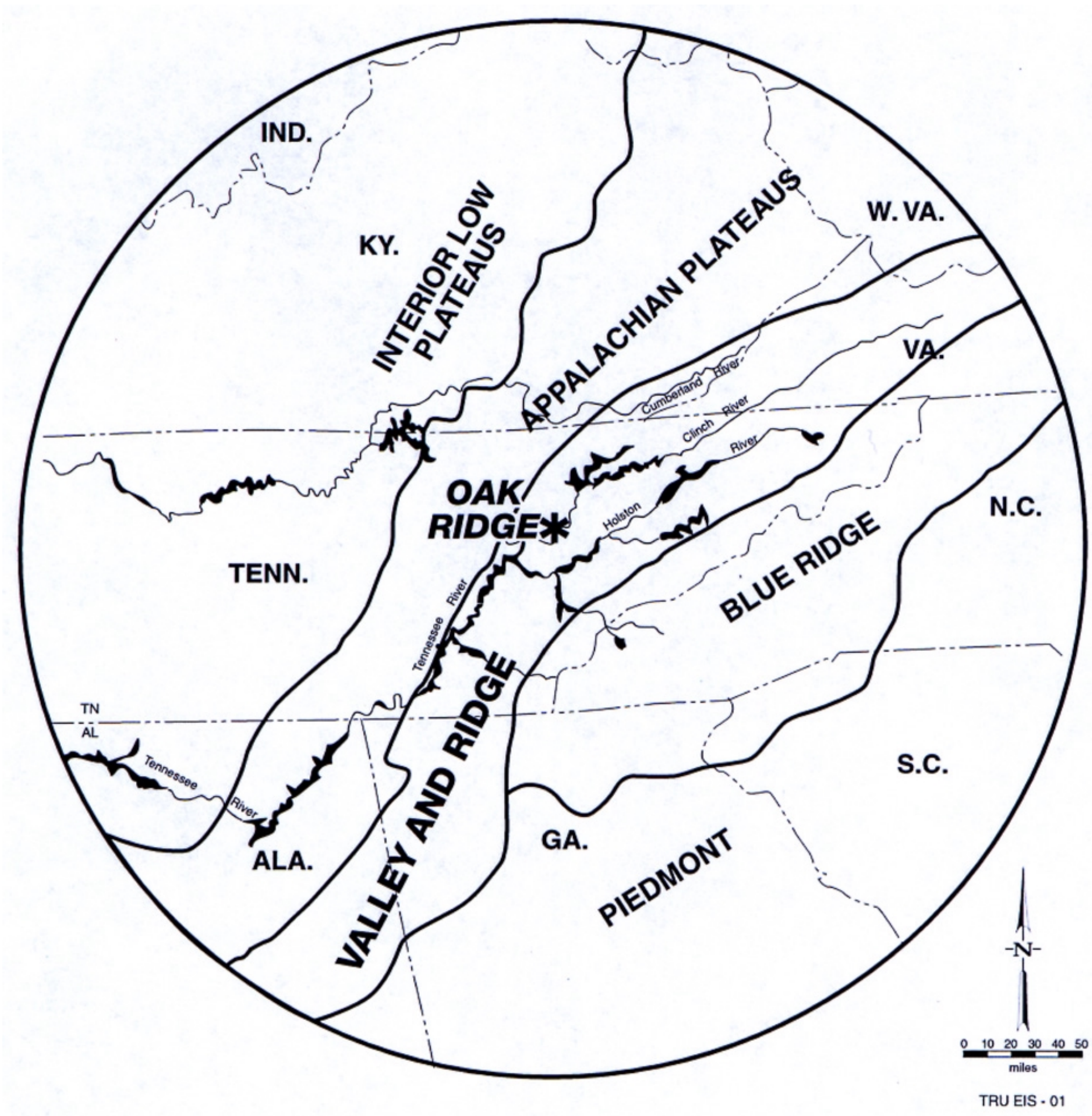


Figure 3-3. Physiographic map of the Southern Appalachian Region.

Treatment Facility site), Haw Ridge, Bethel Valley (containing the main ORNL plant area), Chestnut Ridge (separating ORNL and the Y-12 Plant), Bear Creek Valley (containing the Y-12 Plant), and Pine Ridge (separating the Y-12 Plant from the City of Oak Ridge). The proposed TRU Waste Treatment Facility site lies within Melton Valley at an elevation of about 224 m (735 ft) above mean sea level. Elevations on the ORR range from 212 to 386 m (695 to 1,266 ft) above mean sea level.

The characteristic structure and resulting topography that defines this province is largely a result of regional tectonic activity that occurred during the Alleghenian orogeny from the middle Pennsylvanian through the early Permian periods (300 to 250 million years ago). This tectonism produced a majority of the prominent Appalachian structures and deformed underlying bedrock through intense compressional folding and low-angle (<10º) thrust faulting (overthrusting). The folding and faulting process produced repeated stratigraphic sequences aligned northeast-southwest, perpendicular to the direction of greatest stress, and characteristically dipping to the southeast. Differential erosion of alternating bedrock units subsequently produced the characteristic topography, with resistant units forming ridges and easily eroded units forming valleys. Typically, the scarp (northwest facing) slopes of the ridges are relatively short, steep, and smooth. The dip slopes (southeast facing) are longer, have a gentler slope, and are dissected by surface streams.

3.4.1 Stratigraphy

Bedrock in the ORR vicinity is of Early Cambrian (about 570 million years ago) to Mississippian age (320 to 345 million years ago) (Figure 3-4). The bedrock units encompass a wide variety of lithologies ranging from pure limestone to dolostone to fine sandstone. The total thickness of the stratigraphic section on the ORR is about 2.5 km (1.6 miles). Four primary geologic units occur on the ORR; these include (from oldest to youngest) the Rome Formation, Conasauga Group, Knox Group, and Chickamauga Group. Younger geologic formations, including Silurian-, Devonian-, and Mississippian-age units, occur in East Fork Valley immediately north of the ORR. The Conasauga Group, Knox Group, and Chickamauga Group are comprised of individual geologic formations that have been combined based on general lithology types and age. Because of their unique lithologies, each of the major stratigraphic units possesses different mechanical characteristics and has responded differently to the strains imparted on them through time. In general, the Maynardville Limestone of the Conasauga Group, the Knox Group, and most of the overlying Chickamauga Group act as brittle, but competent, units within the major thrust sheets in the ORR vicinity. The Rome Formation, all of the Conasauga Group below the Maynardville Limestone, and the Moccasin Formation of the Chickamauga Group (weak units) readily deform under stress; these units often contain fault planes along which movement has occurred. These faults have been largely inactive in recent geologic time. The Rome Formation and Knox Group are chemically resistant to weathering; thus, these units form the principal ridges on the ORR. The Chickamauga Group and Conasauga Group formations underlie the valleys.

The Consauga Group underlies the Melton Valley which contains the proposed TRU Waste Treatment Facility site (Figure 3-5). Strata within the Consauga Group include (from the oldest to youngest) the Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and the Maynardville Limestone. Strata within the Conasauga Group consist of variable limestone and shale lithologies. The Pumpkin Valley, Rogersville, and Nolichucky Shale are comprised primarily of shale with subordinate limestone content present as thin interbeds or discontinuous stringers. The Rutledge Limestone and Maryville Limestone contain a significant percentage of carbonate (about 40%, respectively); limestone beds up to 6 m (20 ft) thick exist at the base of the Rutledge Limestone, whereas limestone beds typically are 0.5 m (1.7 ft) in the Maryville Liimestone (Hatcher et al. 1992). The Maynardville Limestone consists of relatively pure limestone and dolostone; only a minor percentage of shale occurs in the upper portion of the unit.

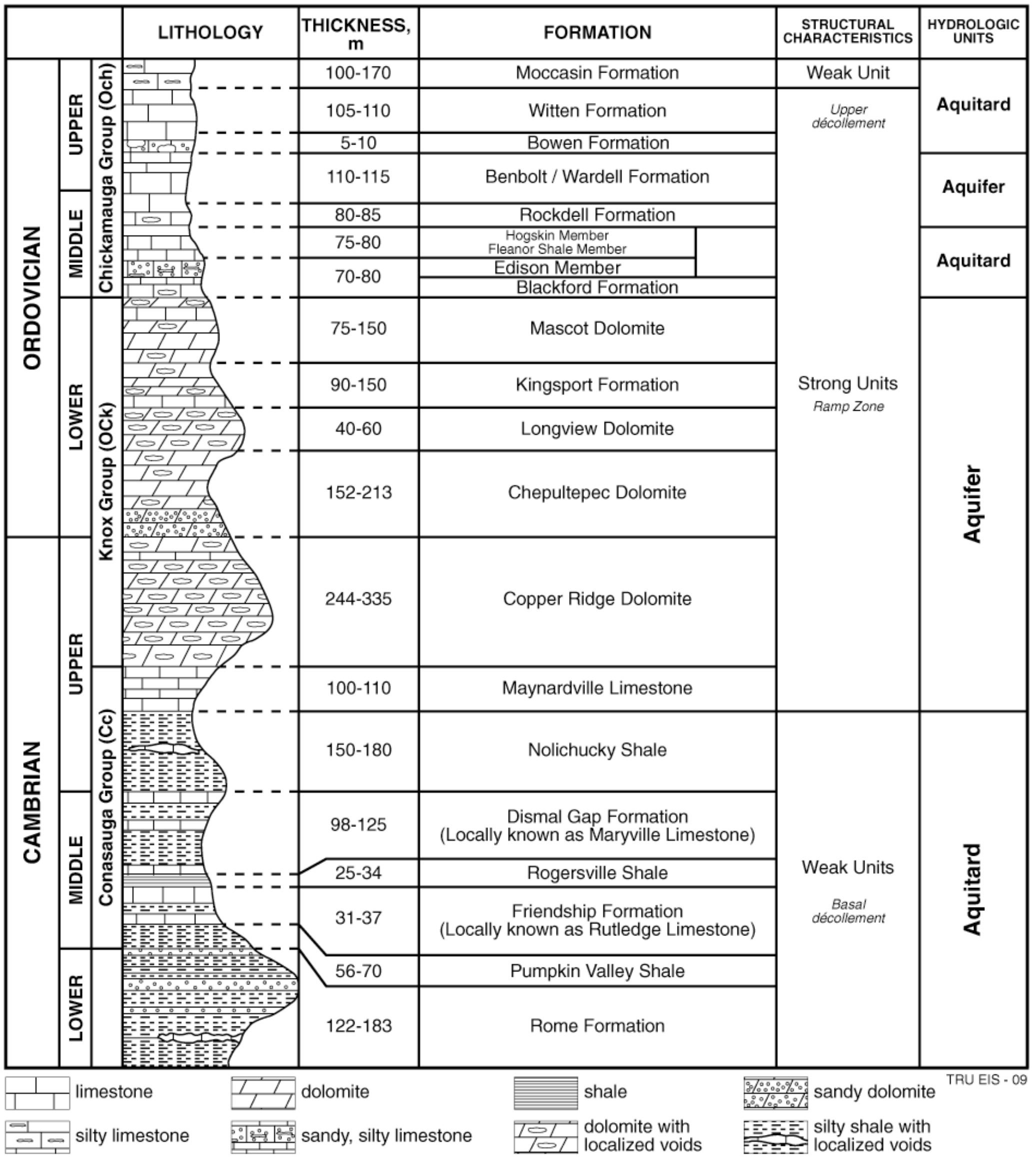


Figure 3-4. Stratigraphic column for the Oak Ridge Reservation.

The TRU Waste Treatment Facility site would be situated over the Cambrian-age Nolichucky Shale. At the proposed location, the Nolichucky Shale consists of dark gray to lesser amounts of dark green, olive green, brown, and black shale and silty shale. Shale beds range from about 2.5 cm (1 in.) to 3 m (9.8 ft) thick and are often fissile in outcrop. The shale-to-limestone content ratio is about 1:1.75. Informally, the Nolichucky is divided into lower, middle, and upper members. The total thickness of the Nolichucky Shale is approximately 57 m (187 ft) in the Copper Creek Thrust Sheet. The surface contact with the Maynardville Limestone lies about 230 m (754 ft) south of the proposed TRU Waste Treatment Facility site. The underlying Maryville Limestone is about 160 m (525 ft) to the north.

3.4.2 Structure

Strata at the proposed TRU Waste Treatment Facility site are oriented in a northeast-southwest direction (average geologic strike is about north 55º east) and dip about 45º to the southeast. The regional compressive tectonic activity that produced the orientation of the bedrock strata also resulted in the development of two major thrust faults: the Copper Creek Fault and the White Oak Mountain

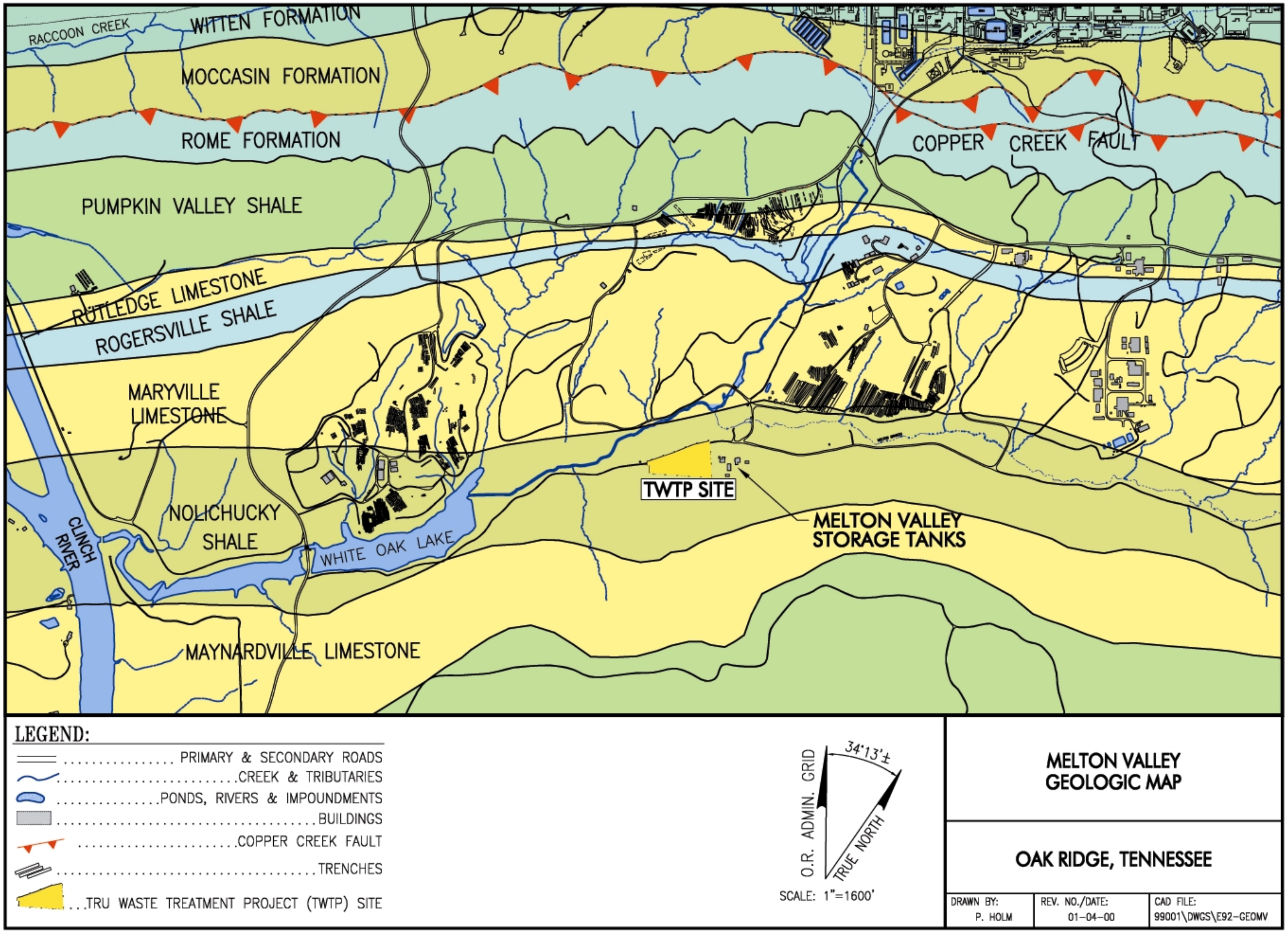


Figure 3-5. Geologic map for Melton Valley.

Fault (Figure 3-6). The strata that overlie and are bounded by these faults are referred to as thrust sheets. The White Oak Mountain thrust sheet is bounded at depth (i.e., soled) by the White Oak Mountain thrust fault and includes all strata between Pine Ridge and Copper Ridge (Figure 3-5). The Copper Creek thrust sheet includes strata south of Copper Ridge extending off of the ORR. Both thrust faults are regional in extent and exhibit several kilometers of translation. As noted previously, these faults formed during the Pennsylvanian-Permian Alleghenian orogeny and have not been historically active.

Bedrock on the ORR is covered with a mantle of residual soil formed by weathering of bedrock in place (saprolite). These residual soils tend to have a high clay content over limestone and dolostone bedrock units and are silty clays over shale-dominated units. The saprolite tends to retain visible parent bedrock characteristics such as fractures and bedding planes and normally has a higher porosity and permeability than the parent material. The residual soils tend to be absent where erosion has removed them near streams and thicker in upland areas and where bedrock contains higher limestone or dolostone content.

Localized folding of bedrock units is prevalent on the ORR. Incompetent strata, such as the Nolichucky Shale, exhibit numerous small-scale folds ranging from less than a meter to several meters in size. Folds within the Copper Creek Thrust Sheet are typically parallel (flexural slip), range from symmetric to asymmetric, plunge gently (<30º) to the northeast or southwest, generally are open, and are upright to steeply inclined (axial surface dip >60º) (Hatcher et al. 1992).

Ancient tectonic activity has also produced extensive fracturing and localized folding of bedrock units. Fractures are abundant within shallow and intermediate bedrock [to depths of about 91 m (300 ft)] and are also retained in bedrock that has been weathered in place (i.e., saprolite). Studies of the orientation of fractures indicate three orientation sets are evident: one that roughly parallels bedding, one steeply dipping set that parallels bedding, and one that is steeply dipping and perpendicular to bedding (Dreier et al. 1987). The fractures form a three-dimensional rectangular network within the bedrock (DOE 1997a). The average fracture density within the Maynardville Limestone and Nolichucky Shale is about 5 per meter in unweathered bedrock. Up to 200 fractures per meter have been measured within saprolite. Fracture densities between 3 and 200 per meter have been observed in outcrops near ORNL (Dreier et al. 1987). Typical fracture lengths are short, ranging from a few centimeters to several meters. Within the Maynardville Limestone, and to a lesser degree in the carbonate sections of the Rutledge Limestone and Maryville Limestone Formations, chemical weathering and solution enlargement of fractures have produced karst features (i.e., conduits and cavities). Cross-cutting fractures and fracture zones play a significant role in the movement of groundwater across the geologic structure of the area. The presence of such features is of concern when considering movement of contaminant at depth, such as deep hydrofracture-injected wastes (DOE 1997a). Additional discussion of groundwater fracture flow is presented in Section 3.5.2.

3.4.3 Soils

Soil contamination exists in many locations of the Melton Valley at ORNL. This valley is primarily used for waste storage and contains many existing above grade and below grade waste storage facilities. TRU constituents have been identified in the soil at the SWSA 5 North trench area.

TRU waste is stored in SWSA 5 North in underground trenches. The waste was stored in either 4-inch-thick concrete casks, or a combination of wood and metal boxes, and then buried in identified trenches. In 1983, one of the casks was removed to evaluate the integrity of the containment

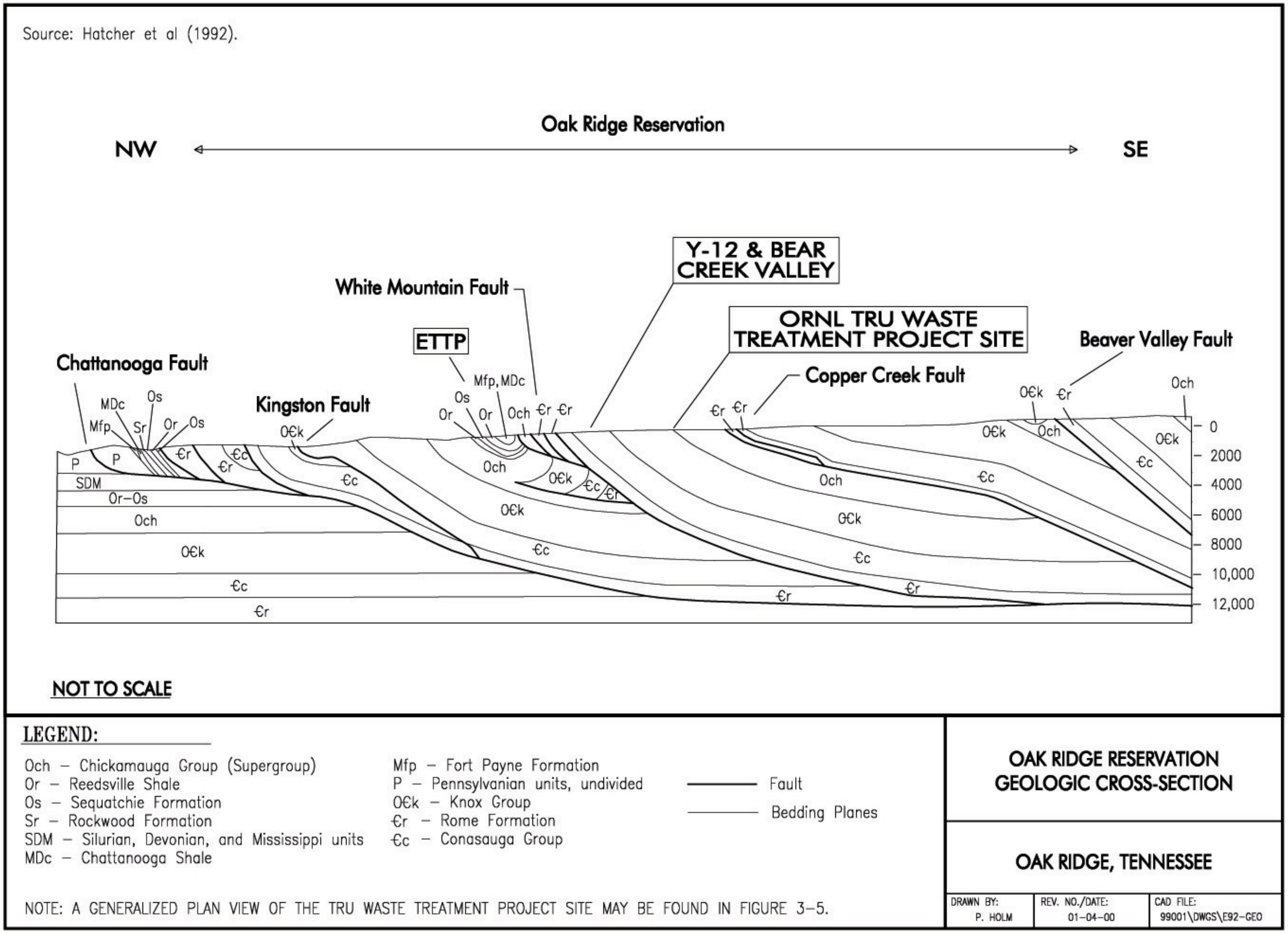


Figure 3-6. Geologic cross-section of the Oak Ridge Reservation.

vessel. Although the hoisting cables were severely rusted and eventually broke during removal, the vessel itself remained in generally good condition. Similar evaluation steps have not been taken for the other containment vessels. Water level data collected in 1993 from in-trench standpipes and nearby monitoring wells show that most of the TRU trenches in the main group of trenches are at least partially inundated during the wet season (DOE 1995). The trench inundation and/or bathtubbing are the most likely mechanisms responsible for the potential release from the TRU trenches to the surrounding soils. Impacted groundwater from these trenches has the potential of discharging into White Oak Creek to the west or to the D-1 Tributary to the south and impacting the subsurface soils and bedrock along this flow path.

Soils at the site are closely tied to local geology and geomorphic processes. Soils at the proposed site formed from rock weathered in place from the underlying Nolichucky Shale bedrock (residuum), from soil and rock transported downslope by gravity from higher topographic positions (colluvium), or from soil and rock transported by Melton Branch and other tributary streams (alluvium) (Hatcher et al. 1992). Soil properties are summarized in Table 3-4.

Table 3-4. Select properties of soils at the proposed TRU Waste Treatment Facility site

Series Number	Parent material	Drainage	Depth	Erosion potential	Roads		Small buildings
					Paved	Unpaved	
300	Nolichucky residuum	Moderately well to somewhat poorly drained	50 to 125 cm (20 to 49 in.)	Low to moderate	Poor	Poor (wetness and high clay content)	Poor (wetness)
301	Nolichucky residuum	Moderately well drained	50 to 100 cm (20 to 39 in.)	High	Fair	Poor (high clay content)	Fair to poor (differential settling)
302	Nolichucky residuum	Moderately well to well drained	50 to 125 cm (20 to 49 in.)	Moderate to high	Poor (high clay content)	Poor (unstable base)	Fair (high clay content)
221	Colluvium from Maynardville and Copper Ridge	Well drained	>150 cm (>59 in.)	High	Fair	Fair (unstable base)	Fair to good
995	Alluvium	Moderately well to well drained	50 to 125 cm (20 to 49 in.)	Very high	Poor (high silt content)	Very poor (very unstable base and high silt content)	Very poor (wetness and high silt content)

3.4.3.1 Residual soils

Soils formed in Nolichucky residuum at the proposed TRU Waste Treatment Facility site include three unnamed soil series, coded as Series Numbers 300, 301, and 302 (Hatcher et al. 1992). Number 300 soils occur on lower side slopes where overland flow and subsurface lateral flow keep the lower subsoil horizons wet during winter and spring. Number 301 soils occupy topographic positions higher in the landscape than Number 300 soils and occupy the largest area underlain by the Nolichucky Shale. Most areas of Number 301 soils were cultivated in the past and led to severe erosion. The high silt and clay content throughout Number 301 soils contributes to frequent downslope movement when these soils become saturated with water. Number 302 soils occur on very gentle slopes (<6%) underlain by the Nolichucky Shale. They are most often found near the top of the formation where beds of clayey limestone are interspersed among the shale layers. Number 302 soils have a clay-enriched subsurface horizon, which is related somewhat to the high clay content of the parent material.

3.4.3.2 Colluvial soils

Colluvial soils at the site include Series Number 221 (Hatcher et al. 1992). These soils formed in material that was transported downslope by gravity from the Maynardville Limestone or Copper Ridge Dolomite, which overlie the Nolichucky on Copper Ridge. Number 221 soils overlie Nolichucky residuum on toeslopes along the bottom of ridges and fan terraces at the bottom of first-order drainageways. Different hydraulic properties of the colluvium and the underlying residuum interrupt the vertical migration of water through the soil profile, resulting in a seasonally perched water in the top part of the soil profile in winter and spring.

3.4.3.3 Alluvial soils

Alluvial soils, coded Series Number 995, formed in alluvium deposited in floodplains of larger (second-order and higher) streams (Hatcher et al. 1992). Number 995 soils occur in the floodplain of Melton Branch, which abuts the proposed TRU Waste Treatment Facility site on the northwest. These soils generally have a high silt and fine sand content in the upper part of the soil profile, which leads to some significant engineering problems. Number 995 soils cannot be compacted and have a very low load-bearing capacity.

3.4.4 Site Stability

A 1989 site characterization study conducted for a previously proposed TRU waste handling and packaging plant about 287 m (1,000 ft) west of the Melton Valley Storage Tanks included installation of 47 soil borings and collection of samples for geotechnical parameters (MMES 1989; EDGE 1989). Data from this investigation showed that residual soils at the site ranged from depths of 0.48 to 5.7 m (1.7 to 20.1 ft). No evidence for sinkhole or karst development was observed. Soils overlying limestone-dominant bedrock were cohesive and stiff to very stiff. Blow counts for these types of soils typically ranged between 2 to 8 counts per 0.14 m (0.5 ft). Samples of residual soil overlying the shale-dominant zones of the Nolichucky Shale were dense and noncohesive. Blow counts typically ranged between 10 and 50 per 0.14 m (0.5 ft). The 1989 geotechnical studies were conducted for the purpose of construction suitability testing in the region around the Melton Valley Storage Tanks, located east of the proposed TRU Waste Treatment Facility site. Borings were generally excavated to 5 m (15 ft) below ground surface or auger refusal, whichever came first. Standard penetration tests were collected in the field, and select samples were collected by standard engineering characteristics analysis (e.g., grain size analysis, moisture content, specific gravity, and Atterberg limits) (EDGE 1989). In general, the results of these suitability tests found that the soils on the proposed TRU Waste Treatment Facility site are typical of the ORR, suitable for construction, and not susceptible to liquefaction or mass movement.

Regional seismicity data for the southeastern United States presented in this EIS are derived from the assessment for the Advanced Neutron Source (ANS) site (Blasing et al. 1992). The ANS site was located about 1.6 km (1 mile) north of the proposed TRU Waste Treatment Facility site. Five tectonic provinces in the southeastern United States have experienced historical strong-motion earthquakes: the Mississippi Embayment, the Atlantic Coastal Plain, the Appalachian Basin, the Piedmont Plateau, and the Interior Low Plateau. The ORR is located within the Appalachian Basin province. Strong-motion earthquakes are those with a Modified Mercalli Intensity of VII or higher (Table 3-5). The Modified Mercalli Intensity scale is currently the preferred indicator for identifying the relative strength of earth movements. The older Richter Scale is shown for comparison (Table 3-6).

Table 3-5. Modified Mercalli Intensity Scale for earthquakes, developed 1931

Intensity	Earthquake Effects
I	Not felt except by a few under exceptionally favorable circumstances.
II	Felt by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Vibration like the passing of a truck.
IV	Felt indoors by many; outdoors by few during the day. Dishes, windows, doors disturbed; walls make creaking sounds. Sensation like a heavy truck striking the building.
V	Felt by nearly everyone; many awakened if sleeping. Some objects broken; cracked plaster in a few places. Disturbances of trees, poles, and other tall objects sometimes noticed.
VI	Felt by all; many scared and run outdoors. Some heavy furniture moved. Structural damage is slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction. Slight to moderate damage in well built ordinary structures; considerable damage in poorly built or badly designed structures.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great damage in poorly built or badly designed structures. Fall of chimneys, factory stacks columns, monuments, and walls. Sand and mud ejected in small amounts. Changes in well water levels.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great damage in substantial buildings. Buildings shifted off of foundations. Underground pipes broken.
X	Some well-built structures destroyed most masonry and frame structures with foundations destroyed. Steel rails bent. Ground badly cracked. Landslides considerable from riverbanks and steep slopes.
XI	Few if any structures remain standing. Bridges destroyed. Steel rails bent greatly. Broad fissures in the ground. Underground pipelines out of service. Earth slumps and land slips in soft ground.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

Table 3-6. Richter Scale of earthquake magnitude

Magnitude	Earthquake Effects
<3.5	Generally not felt, but recorded by instrumentation
3.5 – 5.4	Often felt, but only minor damage detected
5.5 – 6.0	Slight damage to structures
6.1 – 6.9	Can be destructive to populous regions
7.0 – 7.9	Major earthquake inflicting serious damage
>8.0	Great earthquake with total destruction to nearby communities

Historical seismicity in the southeastern United States has largely been correlative with surface or shallow geologic structures above the crystalline basement rock. A large majority of seismic activity associated with geologic structures above basement rocks is of low intensity. Of the large historical earthquakes in the southeastern United States, most have been determined to be associated with two types of structures: basement rifts and Triassic Basins. Some large earthquakes have not been correlated with any specific geologic structures. Little is known about the precise relationships between earthquakes and basement structures because the historical seismic record is too short, and the types and locations of basement structures are poorly understood. Basement rifts typically are late Precambrian to early Cambrian age and underlie the Interior Low Plateau, Mississippi Embayment, and Appalachian Basin provinces. The Precambrian rift basins are believed to have formed about 820 million years ago during separation of the North American ancestral continent from the African, European, and South American ancestral continent. Triassic basins are rift basins associated with the early opening of the Atlantic Ocean during the late Triassic period (about 200 million years ago). Triassic rift basins are buried beneath the Atlantic Coastal Plain in Georgia and South Carolina, are exposed at the surface in North Carolina and Virginia, and are exposed within the Appalachian Basin from Maryland to Connecticut. The closest Triassic Basin is located about 515 km (320 miles) east of the ORR. Earthquakes detected in association with Triassic Basins are thought to be a result of reactivated faults bounding them. The following discussion presents information regarding the 10 strongest historical quakes in the southeastern United States.

The strongest historical earthquakes in the southeast occurred in the Mississippi Embayment in 1811 along the New Madrid Seismic Zone in northwest Tennessee, northeast Arkansas, and southeast Missouri (Figure 3-7). This seismic zone, associated with the Precambrian Reelfoot Rift and Rough Creek Graben, is sourced from basement rock and offsets Holocene (recent) rocks of the Mississippi

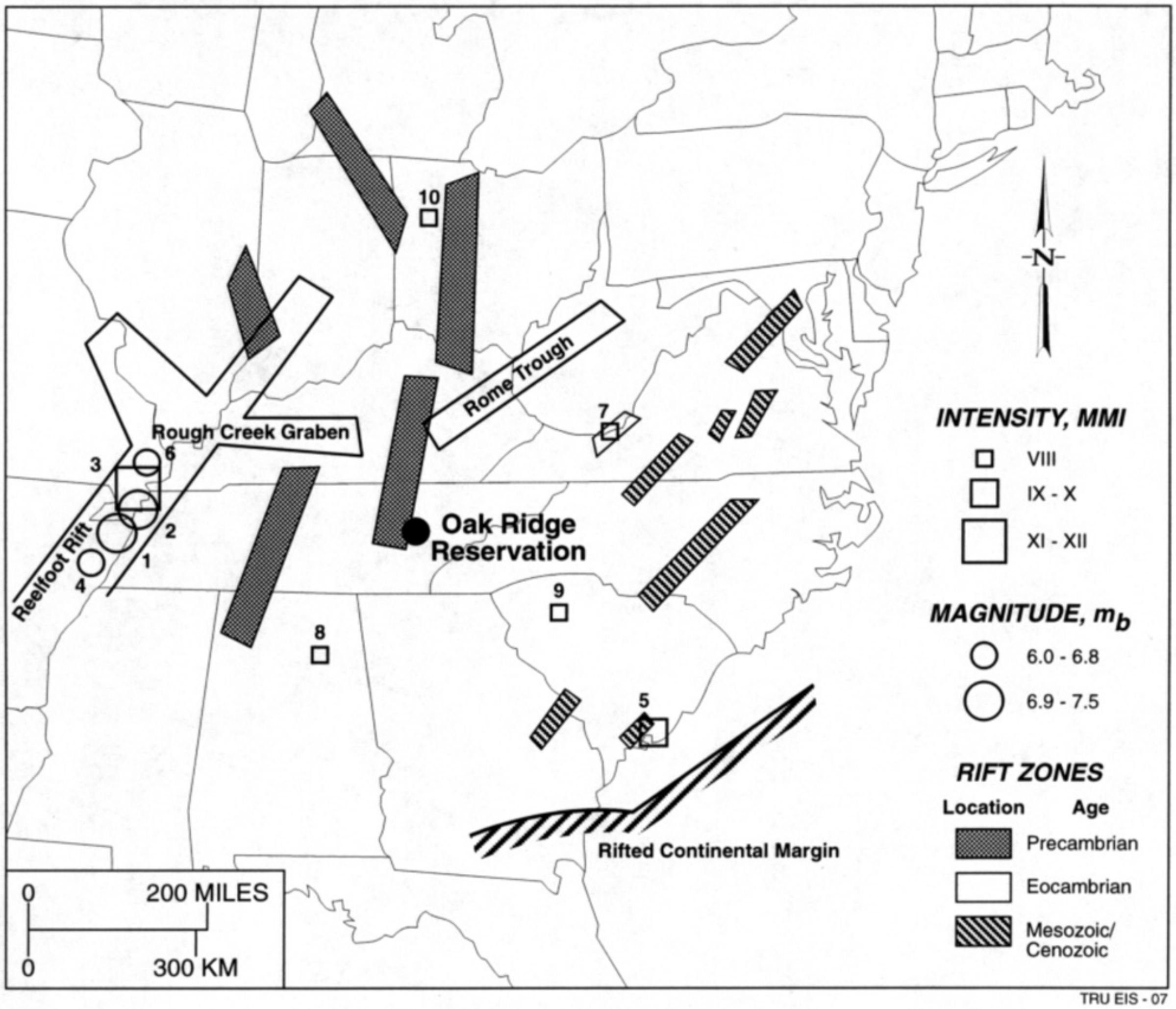


Figure 3-7. Southeast region basement structures and major earthquakes. Depending on the method of measurements when the earthquake occurred, this graphic indicates the measurements as either intensity (Modified Mercalli Index) or magnitude.

Embayment. The strongest quake within the Atlantic Coastal Plain province occurred in 1886 and had an epicenter located at Charleston, South Carolina (Site Number 5; Figure 3-7). The geologic structure suspected of producing this earthquake is faulting associated with the rifted eastern continental margin (Triassic age). Within the Appalachian Basin, the strongest historical quake occurred in 1897 near Giles County, Virginia (Site Number 7; Figure 3-7). The epicenter for this quake correlates to a late Precambrian to early Cambrian basement rift structure buried beneath Paleozoic sedimentary rocks. Another strong-motion quake occurred in northeast Alabama and is not associated with any known basement structure or Triassic rift basin. The strongest known earthquake within the Piedmont Plateau province occurred in 1913 with an epicenter near Spartanburg, South Carolina (Site Number 9; Figure 3-7). This quake is not associated with any known basement structure or Triassic Rift basin. Within the Interior Low Plateau province, the strongest known earthquake occurred near Anna, Ohio, in

1937. The epicenter for this earthquake was near the junction of two Precambrian basement rift zones. Within 100 km (60 miles) of the ORR, the strongest historical earthquake occurred near Maryville and Alcoa, Tennessee, in 1973 and had a magnitude of 4.7. The intensity at ORNL has been estimated at about IV (Modified Mercalli), and there was no observed damage (DOE 1979). An earthquake having a magnitude of 4.2 was recorded in 1844 in the vicinity of west Knoxville, located about 38 km (25 miles) from the proposed TRU Waste Treatment Facility site (USGS 1999). An additional quake having a magnitude of 4.1 occurred in 1913 in the west Knoxville vicinity. No associated basement structure is identified with these seismic events.

According to Johnston et al. (1995) and Powell et al. (1994), a well-defined, linear zone of seismic activity exists along the southeastern border of Tennessee and North Carolina. Powell et al. (1994) states, "This zone produced the second highest release of seismic strain energy in the United States east of the Rocky Mountains during the last decade." This linear seismic zone is only second to the New Madrid seismic zone in Western Tennessee. The zone in eastern Tennessee is approximately 300 km long by 50 km wide and has not produced a damaging earthquake in historical time. The largest recorded earthquake had a magnitude of 4.6 (Powell et al. 1994).

No evidence for capable faults exists within the Appalachian Basin in the vicinity of the ORR (Blasing et al. 1992). Available seismic data and geologic studies do not indicate that regional Paleozoic faults have been reactivated during modern times. The closest capable fault (defined as having the capacity for seismic movement) is within the New Madrid seismic zone, approximately 480 km (300 miles) west of the ORR. However, earthquake energies could be transmitted from adjacent physiographic provinces where strong earthquakes have occurred in historical times. The ORR is located in Seismic Zone 2, where a probability of seismic damage is moderate (BOCA 1990). Based on available historical seismic data and factoring in dampening effects of distance, the expected earthquake intensities for the ORR as a result of historical strong-motion earthquakes may be estimated. Table 3-7 presents the maximum expected seismic intensity at the ORR based on the strongest intensity historical earthquakes in each of the five tectonic provinces discussed above.

Table 3-7. Maximum historical earthquakes and the maximum Modified Mercalli Intensity and their peak ground accelerations at the ORR[a]

Province	Maximum historical MMI[b]	Distance to ORR km (miles)	Maximum MMI[b] expected at ORR
Appalachian Basin	VIII	N/A[c]	VIII
Atlantic Coastal Plain	X	320 (200)	VII
Interior Low Plateau	VIII	50 (30)	VII
Reelfoot Rift Zone	XI–XII	400 (250)	VII
Piedmont Province	VII–VIII	200 (125)	V–VI

[a]Blasing et al. 1992.
[b]MMI - Modified Mercalli Intensity.
[c]The ORR is located within the Appalachian Basin; maximum expected intensity for this province is based on the 1897 Giles County, Virginia, earthquake.

Additional studies of potential seismic movement on the ORR have been conducted in support of final safety analysis reports (FSARs) in accordance with DOE-STD-1020. Specific studies have not been conducted at the proposed TRU Waste Treatment Facility site; however, data compiled for the South Tank Farm, located in the main plant area of ORNL in Bethel Valley, and ground-supported facilities at the Y-12 Plant in Bear Creek Valley (DOE 1998a) provide reasonable indicators of annual probability of exceedance and expected peak ground acceleration. Figure 3-8 shows the results of these seismic hazard studies for peak horizontal rock acceleration.

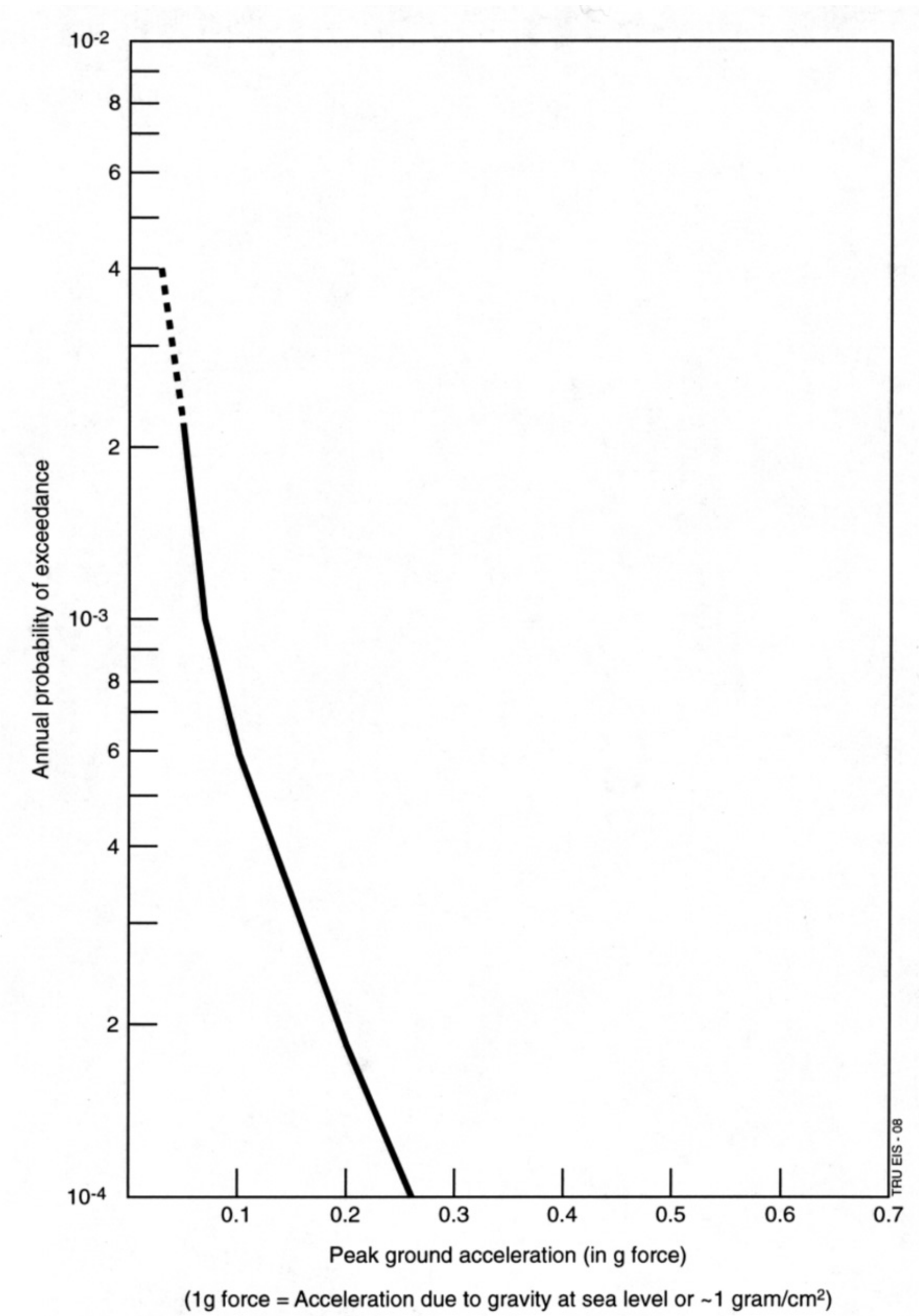


Figure 3-8. Peak ground acceleration and associated annual probability of exceedance for the Oak Ridge Reservation.

Those soil-supported facilities include an amplification factor of about 2.5 and are shown in Table 3-8. The design earthquake for a 50-year-life facility, with a 100-year seismic event probability is 0.06 peak ground acceleration.

Table 3-8. Seismic ground acceleration for soil-supported facilities[a]

Effective peak ground acceleration (g)	Recurrence interval (year)
0.15	500
0.20	1,000
0.30	2,000
0.65	10,000

[a]Source: DOE 1998a.
g = g force.

3.5 WATER AND WATER QUALITY

This section discusses the surface water resources (Section 3.5.1) and groundwater resources (Section 3.5.2) for the White Oak Creek Watershed, which includes the Melton Valley Watershed, where the site of the proposed TRU Waste Treatment Facility is located. The White Oak Creek Watershed defines the resource area most likely to be effected by the proposed action.

3.5.1 Surface Water

The proposed TRU Waste Treatment Facility site would be located within the Melton Valley Watershed portion of the White Oak Creek Watershed (Figure 3-9). The total drainage area of the White Oak Creek Watershed is approximately 6.15 square miles. There are no permanent surface water bodies or springs within the proposed facility site borders. However, there are two perennial streams (White Oak Creek and Melton Branch), one unnamed wet-weather tributary to White Oak Creek, and one lake (White Oak Lake) within close proximity to the proposed facility, which the State of Tennessee has determined to be Waters of the State. Melton Branch, a tributary to White Oak Creek, is about 61 m (200 ft) from the northern border of the proposed facility. White Oak Creek, which flows south into White Oak Lake, is approximately 152 m (500 ft) to the west of the proposed facility site border and is the main nearby surface water body. White Oak Lake is approximately 0.4 km (0.25 mile) downstream from where the proposed facility is adjacent to White Oak Creek. White Oak Lake discharges into the Clinch River, approximately 2.4 km (1.5 miles) downstream from the proposed TRU Waste Treatment Facility site.

White Oak Creek is a fourth-order stream that originates from springs on the southeast slopes of Chestnut Ridge, which separates ORNL from the Y-12 Plant. The creek receives natural runoff and water from the spring, as well as process water discharges, treated sewage effluent, and cooling water from ORNL facilities located in Bethel Valley, before flowing though the gap in Haw Ridge where it enters Melton Valley. Melton Branch is a third-order stream (relative to the branching of the primary stream and defines the stream's or tributary's position in the watershed) and the primary tributary to White Oak Creek. Melton Branch flows westerly in the Melton Valley portion of the White Oak Creek Watershed, joining White Oak Creek approximately 114 m (375 ft) from the proposed TRU Waste Treatment Facility site border. White Oak Lake is impounded by White Oak Dam and has a normal pool elevation of 227.1 m (745 ft) above mean sea level. Flow from the White Oak Dam discharges into the White Oak Creek Embayment, approximately 0.97 km (0.6 mile) above the confluence with the Clinch River.

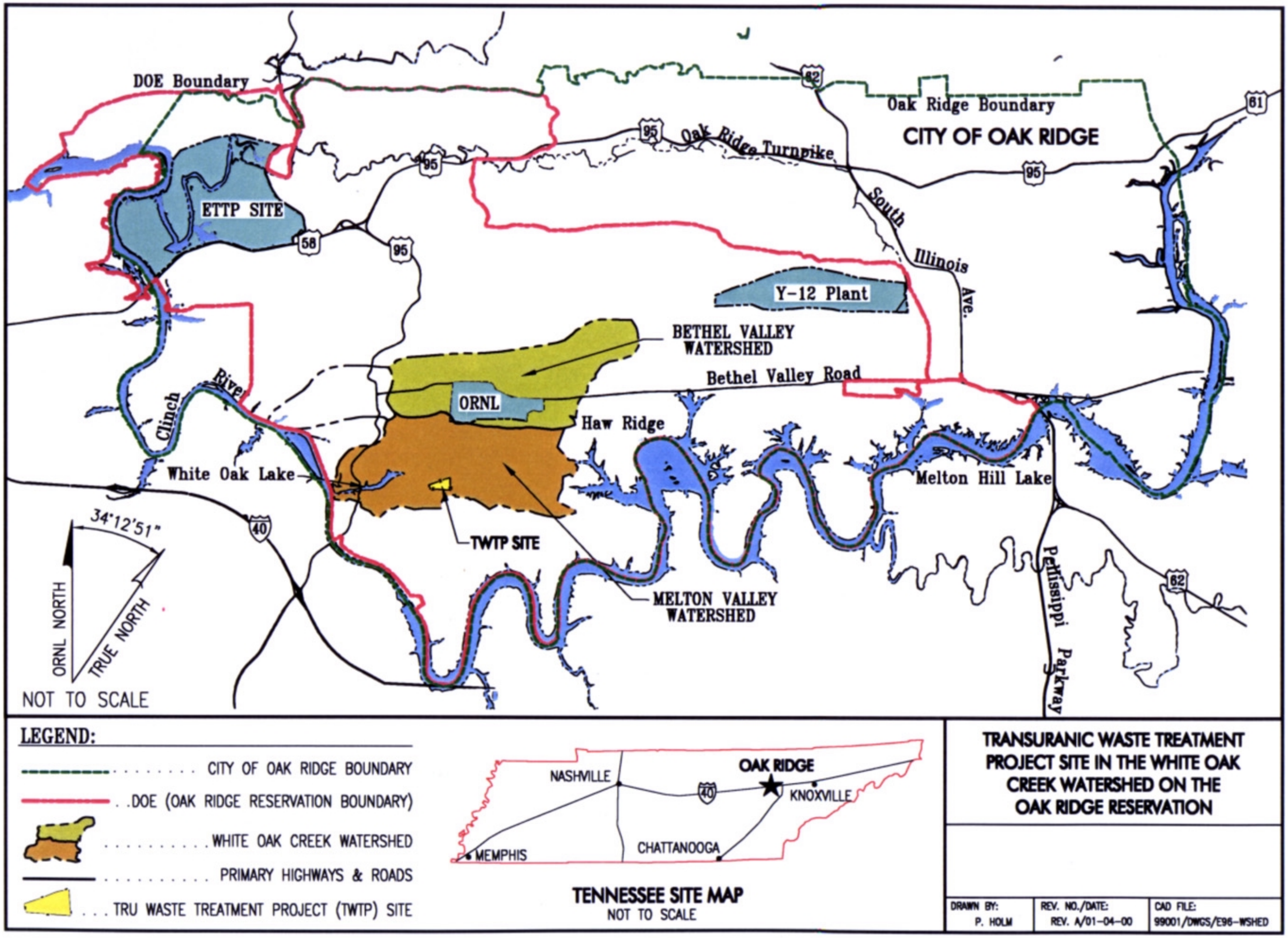


Figure 3-9. Map showing the location of the White Oak Creek Watershed in relation to the Oak Ridge Reservation and the proposed TRU Waste Treatment Facility Site.

Continuous stream discharge data have been collected from several water monitoring stations on the White Oak Creek Watershed for years. Monitoring locations that are relatively close to the proposed TRU Waste Treatment Facility site are shown in Figure 3-10. Average discharges at these locations for 1993 and 1994 are summarized in the Melton Valley Remedial Investigation (DOE 1997a). The average discharge at White Oak Creek weir, which is approximately 183 m (600 ft) upstream of the confluence of Melton Branch into White Oak Creek, was 328 L/s. This discharge represents the surface water input to the system. The average discharge at Melton Branch weir on Melton Branch, which is approximately 213 m (700 ft) upstream of the proposed facility border, is 87.9 L/s. The average discharge at the White Oak Dam was 481 L/s, which represents output from the White Oak Creek Watershed.

Surface water sampling for chemical and radionuclide analyses has been ongoing for several years in White Oak Creek (Sample Station X14), Melton Branch (Sample Station X13), and White Oak Lake Dam (Sample Station X15) as part of the Biological Monitoring and Abatement Program requirements for the ORNL 1997 National Pollutant Discharge Elimination System (NPDES) Permit TN0002941, as well as the ORR Environmental Monitoring Plan. The permit limits and compliance statistics for the NPDES sampling are presented in Table 3-9. Table 3-9 shows the daily and monthly permit limits for a variety of water quality parameters. It also shows the number of noncompliances per parameter in relation to the number of samples taken for that parameter. For example, in 1997 there were two exceedances of in-stream chlorine at the Melton Branch X-16 location out of 147 samples [14 of the 19 noncompliance measurements were for total residual chlorine (TRC)]. Dechlorination systems were upgraded to guard against reoccurrences (ORNL 1998), resulting in only two noncompliances for TRC at ORNL in 1998 (ORNL 1999a). The exceedances for the daily maximum concentration and daily maximum loading of the carbonaceous biochemical oxygen demand (CBOD) limit on October 9, 1997, were addressed by a corrective measure on the dechlorination system feed modification at the Sewage Treatment Plant, which resulted in no more exceedances after the one on October 9, 1997 (ORNL 1999a). One Category IV outfall, 302, had one pH measurement of 9.1 on November 17, 1997, which exceeded the permit upper limit of 9.0. A corrective action to identify and repair an underground leak in a waste treatment system component prevented any additional pH noncompliances at the outfall that year, but did allow an additional exceedance of pH 9.6 on January 13, 1998 (ORNL 1999a).

Concentrations of total strontium at all three locations were greater than 4% of the relevant derived concentration guides in 1997 (ORNL 1998). Concentrations of tritium at Melton Branch (Sample Station X-13) and White Oak Lake Dam (Sample Station X15) were greater than 4% of the derived concentration guidelines in 1997 sampling. Figure 3-11, from the Annual Site Environmental Report (ORNL 1998), shows the discharges in curies of several radionuclides at White Oak Dam from 1993–97.

Water samples were collected from four locations on White Oak Creek in November 1997 and analyzed for mercury (ORNL 1998). The most upstream location from ORNL (White Oak Creek kilometer 6.8) had 11 ng/L, which was similar to background or reference streams in East Tennessee. The mercury concentrations at White Oak Creek kilometer 2.9 and White Oak Lake Dam were 160 and 63 ng/L, respectively.

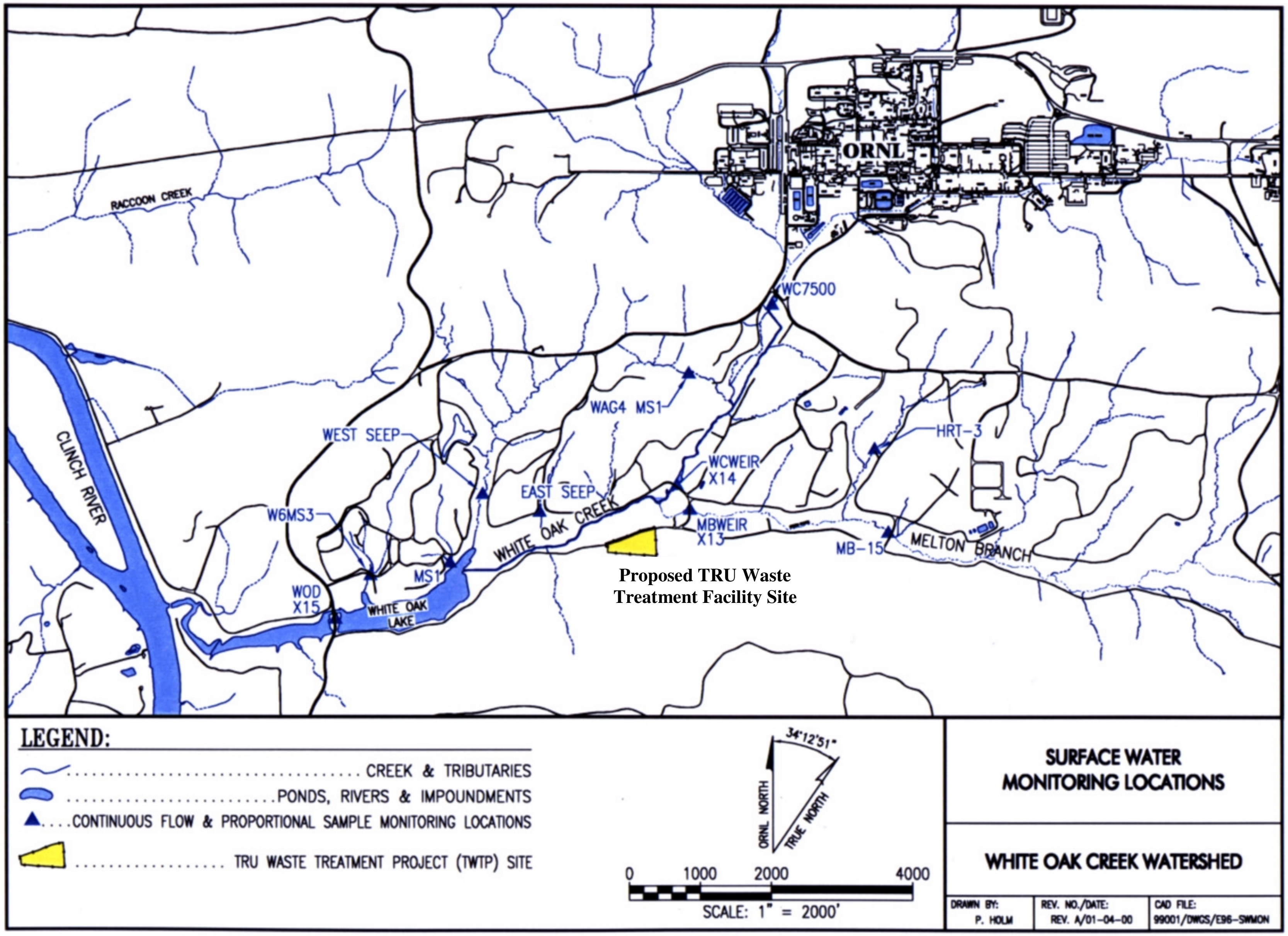


Figure 3-10. Map of surface water monitoring locations in White Oak Creek Watershed near the proposed TRU Waste Treatment Facility.

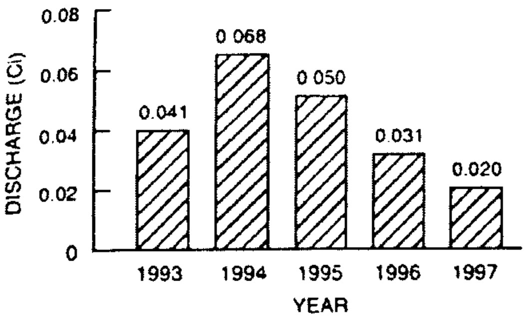
Table 3-9. ORNL NPDES Permit TN0002941 permit limits and compliance statistics (1997)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg. (kg/d)	Daily max. (kg/d)	Monthly avg. (mg/L)	Daily max. (mg/L)	Daily min. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	96-h LC_{50} for *Cerodaphnia* (%)					41.1	0	3	100
	96-h LC_{50} for fathead minnows (%)					41.1	0	3	100
	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	79	100
	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	64	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		2	143	99
	Dissolved oxygen					6	0	144	100
	Fecal coliform (col/100 mL)			1000	5000		0	144	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					12.3	0	3	100
	No-observed-effect conc. for fathead minnows (%)					12.3	0	3	100
	Oil and grease	8.7	13.1	10	15		0	144	100
	pH (std. units)				9	6	0	144	100
	Total residual chlorine			0.038	0.066		2	147	99
	Total suspended solids	26.2	39.2	30	45		0	143	100
X02 (Coal Yard Runoff Treatment Facility)	96-h LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
	96-h LC_{50} for fathead minnows (%)					4.2	0	4	100
	Copper, total			0.07	0.11		0	22	100
	Iron, total			1.0	1.0		0	22	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					1.3	0	2	100
	No-observed-effect conc. for fathead minnows (%)					1.3	0	2	100
	Oil and grease			10	15		0	48	100
	pH (std. Units)				9.0	6.0	0	48	100
	Selenium, total			0.22	0.95		0	22	100
	Silver, total				0.008		0	22	100
	Total suspended solids				50		0	48	100
	Zinc, total			0.87	0.95		0	22	100

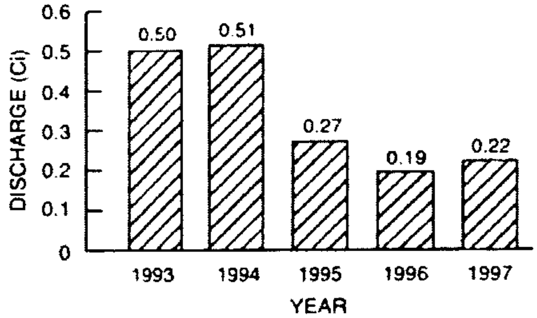
Table 3-9. ORNL NPDES Permit TN0002941 permit limits and compliance statistics 1997 (continued)

Discharge point	Effluent parameters	Permit limits: Monthly avg. (kg/d)	Permit limits: Daily max. (kg/d)	Permit limits: Monthly avg. (mg/L)	Permit limits: Daily max. (mg/L)	Permit limits: Daily min. (mg/L)	Permit compliance: Number of noncompliances	Permit compliance: Number of samples	Permit compliance: Percentage of compliance[a]
X12 (Nonradiological Wastewater Treatment Facility)	96-h LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
	96-h LC_{50} for fathead minnows (%)					100	0	4	100
	Cadmium, total	0.79	2.09	0.008	0.034		0	48	100
	Chromium, total	5.18	8.39	0.22	0.44		0	48	100
	Copper, total	6.27	10.24	0.07	0.11		0	48	100
	Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
	Lead, total	1.3	2.09	0.028	0.69		0	48	100
	Nickel, total	7.21	12.06	0.87	3.98		0	48	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					30.9	0	4	100
	No-observed-effect conc. for fathead minnows (%)					30.9	0	4	100
	Oil and grease	30.3	45.4	10	15		0	48	100
	pH (std. units)				9.0	6.0	0	144	100
	Silver, total	0.73	1.3		0.008		0	48	100
	Temperature (°C)				30.5		0	144	100
	Total toxic organics		6.45		2.13		0	11	100
	Zinc, total	4.48	7.91	0.87	0.95		0	48	100
In-stream chlorine monitoring points	Total residual oxidant			0.011	0.019		2	242	99
Steam condensate outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	17	100
Groundwater/ pump water outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	8	100
Cooling tower blowdown outfalls	pH (std. units)				9.0	6.0	0	2	100
Category I outfalls	pH (std. units)				9.0	6.0	0	13	100
Category II outfalls	pH (std. units)				9.0	6.0	0	15	100
Category III outfalls	pH (std. units)				9.0	6.0	0	63	100
Category IV outfalls	pH (std. units)				9.0	6.0	1	296	100
Cooling tower blowdown/ cooling water outfalls	pH (std. units)				9.0	6.0	0	44	100
	Total residual oxidant			0.11	0.019		12	53	77

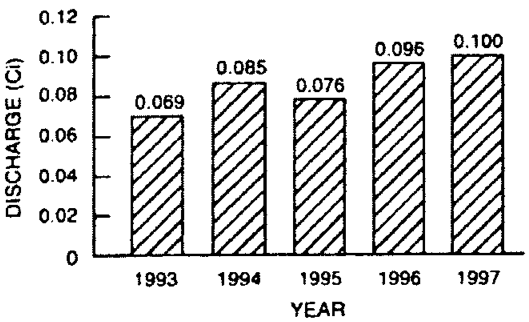
[a]Percent compliance = 100 – [(number of noncompliances/number of samples) * 100].
d = day; kg = kilogram; L = liter; and mg = milligram.
NPDES = National Pollutant Discharge Elimination System.
Period of coverage – January 1 to December 31, 1997.
Source: Oak Ridge National Laboratory (1998).



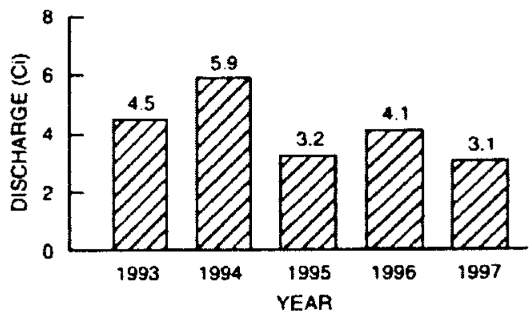
(a) Cobalt-60 discharges at White Oak Dam, 1993–97.



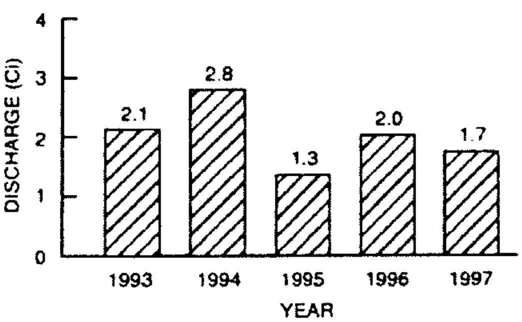
(b) Cesium-137 discharges at White Oak Dam, 1993–97.



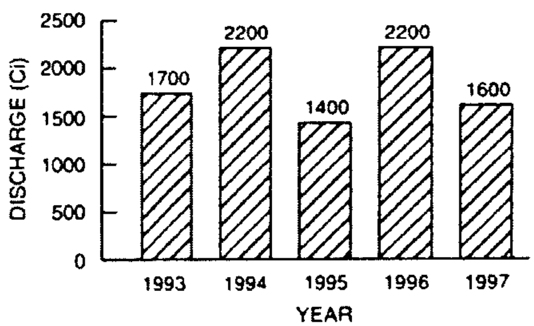
(c) Gross alpha discharges at White Oak Dam, 1993–97.



(d) Gross beta discharges at White Oak Dam, 1993–97.



(e) Total radioactive strontium discharges at White Oak Dam, 1993–97.



(f) Tritium discharges at White Oak Dam, 1993–97.

Figure 3-11. Discharge (in curies) of various radionuclides at White Oak Dam, 1993–97.

In-stream toxicity monitoring at White Oak Creek, Melton Branch, and White Oak Lake, as part of the Biological Monitoring and Abatement Program, was terminated in 1997 because toxicity had not been detected for the previous several years (ORNL 1998). Although wastewater from the Sewage Treatment Plant and two other facilities at ORNL is evaluated for toxicity, these facilities are too far upstream from the proposed TRU Waste Treatment Facility site for the toxicity results to be relevant.

Detailed results of the water sampling under the Environmental Monitoring Plan for White Oak Creek, White Oak Lake, and Melton Branch for 1997 are presented in ORNL 1998. The sampling frequency and sample parameters for these locations are presented in Table 3-10.

Table 3-10. Locations, frequency, and parameters for the Environmental Monitoring Plan surface water sampling at ORNL

Location (K indicates kilometer)	Frequency	Parameters
Melton Branch (K 0.2); Melton Branch downstream from ORNL	Bimonthly (Jan., Mar., May, July, Sept., Nov.)	Gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, and field measurements[a]
White Oak Creek (K 1.0); White Oak Lake at White Oak Dam	Monthly	PCBs, gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, and field measurements[a]
White Oak Creek (K 2.6); White Oak Creek downstream from ORNL	Bimonthly (Jan., Mar., May, July, Sept., Nov.)	Gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, and field measurements[a]
White Oak Creek (K 6.8); White Oak Creek upstream from ORNL	Quarterly (Feb., May, Aug., Nov.)	Gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, and field measurements[a]

[a]Dissolved oxygen, pH, and temperature.
ORNL = Oak Ridge National Laboratory.
PCB = polychlorinated biphenyl.
Source: ORNL (1998).

Radionuclides were detected (statistically significant at the 95% confidence interval) at all three locations (Table 3-11). The highest levels of gross beta, total radioactive strontium, and tritium were at these three locations; however, there is no regulatory standard for gross levels of radioactivity, as standards are done on a radionuclide basis. PCB Aroclor-1254 was detected in 5 of 12 samples at the White Oak Lake Dam (0.36 ± 0.087 mg/L).

Table 3-11. Summary of radionuclide activities during the 1997 Environmental Monitoring Plan surface water sampling

Parameter (all activities are pCi/L, mean ± one standard deviation)	Location		
	White Oak Creek (White Oak Creek kilometer 2.0) M = 12	White Oak Lake (White Oak Creek kilometer 1.0) M = 6	Melton Branch (Melton Branch kilometer 0.2) M = 6
Gross beta	280 ± 19	180 ± 20	490 ± 63
Total radioactive strontium	130 ± 8.3	82 ± 7.7	250 ± 41
Tritium	99,000 ±12,000	18,000 ± 2,000	470,000 ± 90,000

M = number of samples.
Source = ORNL (1998).

ORNL treats over 180 million gal per year of non-radiological wastewater, and typically has over 650,000 gal of hold-up capacity for this type of wastewater upon receipt at their waste water treatment facility. The Y-12 Plant is permitted to discharge up to 1.4 million gal per day to the City of Oak Ridge's wastewater treatment system, and during 1996, this flow averaged about 0.854 million gal per day. The ETTP provides its own treatment of sanitary wastewater and is currently operating under capacity. The City of Oak Ridge has overall design capacity for treating up to 5.87 million gal per day and is currently operating under capacity (Roy 1999).

In summary, the surface water from White Oak Creek, White Oak Lake, and Melton Branch contains elevated concentrations of radionuclides (total strontium and tritium), mercury, and PCBs relative to background or reference streams. The elevated surface water concentrations of mercury and PCBs have resulted in elevated concentrations of these constituents in fish from these locations as indicated in Section 3.3.3. However, the overall water quality is good, such that no toxicity to aquatic organisms had been observed for several years and the toxicity testing was discontinued in 1997.

3.5.2 Groundwater

The *Remedial Investigation Report on the Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 1997a), served as the primary source of information for the current groundwater conditions in the Melton Valley Watershed on the ORR.

3.5.2.1 Regional conceptual model

Solomon et al. (1992) developed a generalized conceptual hydrologic framework for the entire ORR including the Melton Valley Watershed at ORNL. The geologic units of the ORR were assigned to two broad hydrologic groups: (1) the Knox aquifer (formed by the Knox Group and the Maynardville Limestone), which is dominated by solution conduits and stores and transmits relatively large volumes of water, and (2) the ORR aquitards (made up of all other geologic units of the ORR), in which flow is controlled by fractures that may store fairly large volumes of groundwater, but transmit only limited amounts. The Melton Valley Watershed is underlain by both geologic units as shown in Figure 3-12. In vertical cross-sections, both the Knox aquifer and the ORR aquitards are further divided into zones, including the storm flow zone, the vadose zone, and the groundwater zone, shown conceptually in Figure 3-13. The storm flow zone is a thin region at the surface in which transient, precipitation-generated flow accounts for a large portion of the water moving through the subsurface. This zone is a major pathway for transporting contaminants from the subsurface to the surface. The vadose zone is a mostly unsaturated zone above the water table. The groundwater zone, which is continuously saturated, is the region where most of the remaining subsurface flow occurs. Zones where permeability is low and groundwater movement is extremely slow are called aquitards.

In most of the Melton Valley Watershed, the water table lies at or somewhat above the bedrock/soil weathering interface. Recharge to the water table can occur both as porous medium flow through the soil and as flow through relict bedding planes and fractures in the soil connecting the surficial soil to the water table. Below the water table, the spatial density, aperture, orientation, and connectivity of fractures control the transmissivity and actual flow paths of groundwater. The predominant groundwater flow and contaminant migration direction in the shallow groundwater system is parallel to local geologic strike because of the abundance of open bedding planes and bed-normal fractures. Small-scale (tens of meters) folds and fracture sets control seepage pathways. Shallow groundwater is observed to migrate via fractures, generally along strike, to local surface water streams. Anthropogenic features, including pipeline trenches and waste burial trenches, can conduct groundwater along their orientations and provide pathways for contaminant transport.

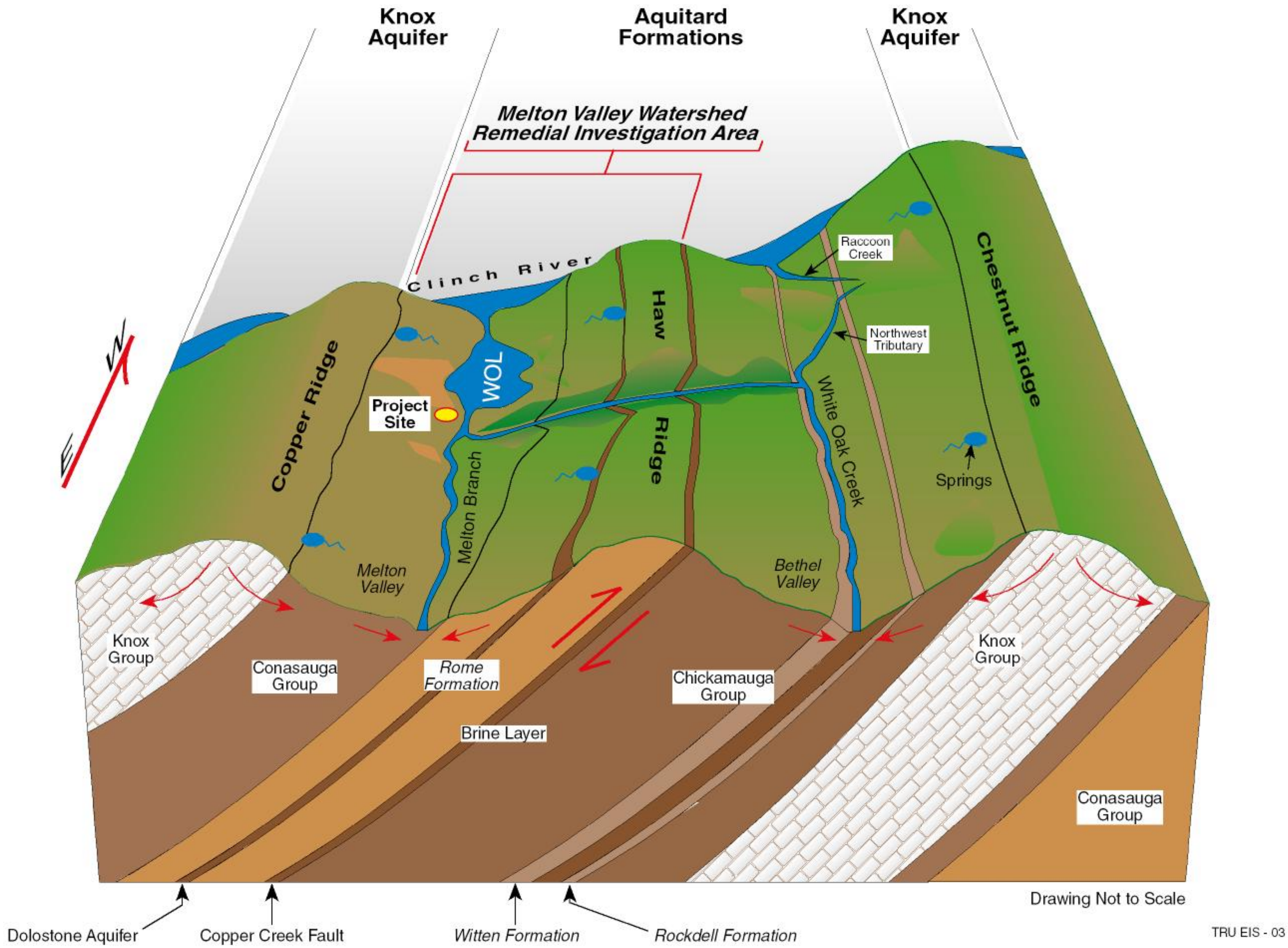


Figure 3-12. Distribution of geologic units in the Melton Valley Watershed Remedial Investigation Area that are assigned to two broad hydrologic groups: the Knox Aquifer and the ORR aquitards.

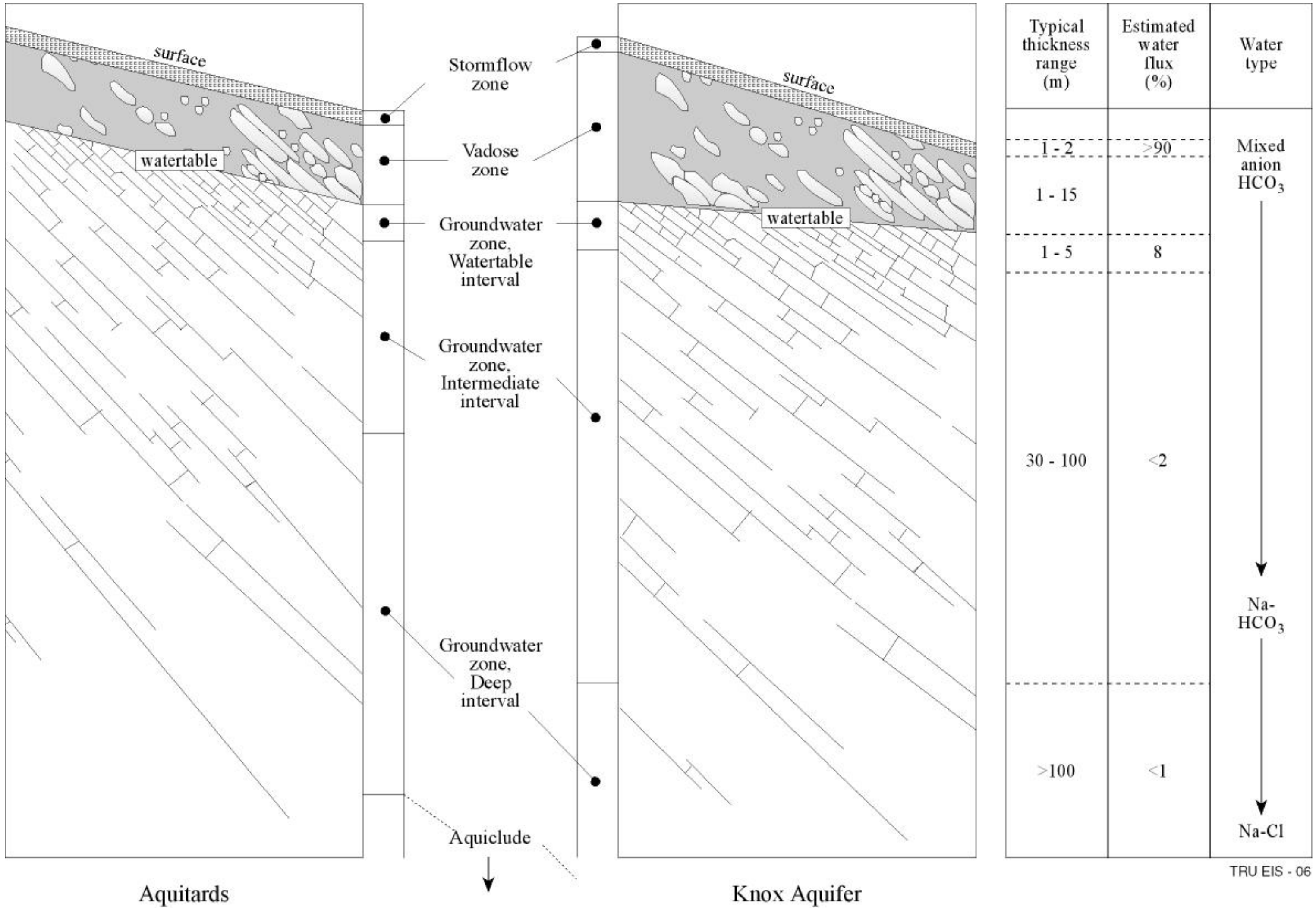


Figure 3-13. Near-surface hydrogeologic zones.

The hydraulic conductivity of subsurface materials is observed to decrease rapidly with increasing depth below the water table. At increasing depths below the water table, the degree of bedrock weathering decreases; thus, fractures tend not to be enlarged. Additionally, overburden pressure tends to keep fractures tightly closed at great depths. Analysis of conductivity tests in screened wells suggests that the spacing of hydraulic active fractures ranges from 7 m (23 ft) near the water table to >35 m (115 ft) at depths of >60 m (197 ft) (Solomon et al. 1992). This decrease in fracture density equates to a decrease in water-transmitting capability in the rock mass with increasing depths. The geochemical profile typically observed in the ORR groundwater system is $CaHCO_3$ groundwater in the water table interval, Na-Ca-HCO_3 groundwater in the Intermediate interval, and NaCl brines in the Deep interval, which reflects fresh water flushing near surface, mixing of water types at intermediate depths, and stagnation of groundwater in the Deep interval.

A compilation of information from numerous investigations performed at specific locations throughout the ORR allowed the development of a valley-wide conceptual model of groundwater flow in Melton Valley. From the large-scale groundwater flow concept, general conditions can be inferred that will control solute of contaminant transport. The key factors that determine the groundwater flow system are soil characteristics, land cover, topography, stratigraphy, and geologic structure. Soil characteristics exert a strong influence on the amount of precipitation that infiltrates the soil and is available for lateral storm flow movement in undisturbed areas of percolation to the water table in areas of disturbed soil profiles. Land cover type exerts a strong influence on evapotranspiration, which effectively removes water from the shallow soils by plant transpiration. Soil characteristics are also important in groundwater flow because much of the "soil" in Melton Valley is residuum of bedrock, and numerous relict fractures are retained in the deeply weathered material. These fractures form a network of avenues for percolation of recharge downward to the water table and also provide avenues for groundwater flow in areas where the water table interval lies in the base of the soil. Stratigraphy and geologic structure influence the groundwater flow system in Melton Valley by determining the types of solid material, and flaws in those materials, through which the groundwater flows. Most of the bedrock materials that underlie Melton Valley have extremely low effective porosity (connected intergranular pores), and most groundwater movement occurs in weathered zones (including residuum near the water table) or in fractures (either in residuum or in bedrock).

Geologic structure in Melton Valley occurs at several scales, each of which has importance to the groundwater flow system. The regional geologic structure is defined by the regional thrust faults such as the Copper Creek Fault. At the regional scale, strike and dip of geologic formations define the three-dimensional orientation and location of the geologic formations. Water-bearing and transmitting properties of the geologic formations vary with the stratigraphic makeup and degree of structural deformation. In Melton Valley the geologic formations with the best water-bearing potential include the Rome Formation and the Maryville Limestone. At the valley-wide scale, there are zones of intraformational folds and faults and various cross-cutting fracture and shear zone orientations that are locally important to groundwater flow. The dimensions of these zones are difficult to define in the Valley and Ridge Province because of extensive soil cover over bedrock. These zones are best identified in large excavations. The thickness of such zones, or outcrop width, is highly variable and, to date, no correlations of individual features within this type of deformation zone have been demonstrated. There is evidence of such intraformational folding and faulting in the Maryville Limestone in a nearly strike-parallel band extending just north of the proposed TRU Waste Treatment Facility. The hydrogeologic importance of such zones varies depending upon the type of bedrock and structural deformation involved. In cases where limestone bedrock is intensely deformed, fracture density can be increased, bedrock weathering may be enhanced, and groundwater flow may increase. Conversely, if such deformation involves mostly shaley bedrock and the deformation causes extensive shearing, fractures may become sealed with rock flour or "gouge," and such zones can become less permeable than surrounding, less deformed bedrock. At the outcrop scale and smaller, individual folds, fractures, or shears ranging from meter or centimeter size down to microscopic features exist. Structural features at these scales are important when they are part of a connected network of fractures and are capable of transmitting groundwater along with its dissolved or suspended constituents. Outcrop-scale structural features are sometimes the observed points of groundwater emanation in seeps or springs.

Hydraulic conductivity measurements have been taken in many wells in the Melton Valley Watershed. Most of the available test results are from various types of single-well tests such as slug tests, rising head recovery tests, and packer tests. Hydraulic conductivity values, obtained by such methods in fractured rock, represent a value obtained by dividing the discharge of the test by the total borehole length included in the test, and thus provide an averaged conductivity value. Such tests overestimate the conductivity of unfractured materials and underestimate the conductivity of the fractures themselves. Hydraulic conductivity measurements collected from the Melton Valley Watershed suggest much higher conductivity in the shallow portion of the groundwater zone than at greater depths.

Borehole testing and empirical observations indicate that in the ORR the combination of stratigraphy (and the orientation of more soluble bedrock zones) and geologic structure combine to provide many dipping, strike-parallel zones of high transmissivity (Lee and Ketelle 1987; Ketelle and Lee 1992). Detailed site investigations at several sites throughout the ORR demonstrate that highly transmissive zones in bedrock are frequently on the order of one to several meters thick. Many of these transmissive zones are confined between lower transmissivity zones, and groundwater flow is parallel to the direction of highest permeability. An example of this condition is seen in the confined freshwater zone in the Upper Rome Formation beneath Melton Valley (DOE 1995). The results of a three-dimensional monitored pumping test (Lee et al. 1992) show that there may be little or no hydraulic connection in the direction perpendicular to confining beds.

In classical analyses of groundwater flow derived from porous media hydraulics, groundwater flow lines that originate from recharge areas near a stream or discharge boundary follow shallow pathways. In the same idealized porous medium case, groundwater flow lines that originate from recharge areas near a groundwater basin boundary show seepage downward and laterally beneath the shallower seepage paths to the discharge boundary. The conceptual model of groundwater movement in the Melton Valley area, derived from site observations, includes similarities and differences in comparison to the classical flow net concept.

Historically, groundwater system descriptions for the Melton Valley area have postulated groundwater zonation on the basis of depth below ground surface citing observed depth-dependent decreases in hydraulic conductivity measurements and geochemical stratification. These observations broadly describe the general conditions; however, they lead the reader to infer that groundwater flow zones are, likewise, nearly horizontally distributed. The combination of interbedded stratigraphy, dipping and fractured structural conditions, and rugged topography leads to highly discrete, local-scale groundwater flow zones with irregular geochemical interfaces in the subsurface. Hydrogeologic investigations performed in the Melton Valley Watershed within the past several years reveal the strong roles that stratigraphy, geologic structure, and topographically derived head differentials play in the groundwater system.

The most prominent features with respect to hydraulic head are a high-head zone in the Rome Formation extending down-dip beneath Haw Ridge and extending beneath the confining layer formed by the Pumpkin Valley Shale. Fresh water recharge on Haw Ridge associated with the Rome Formation and fractured and weathered bedrock in the Copper Creek Fault Zone are responsible for this feature (DOE 1995). A well that penetrated this interval flowed artesian at 40 gal per minute for several days before it was plugged with no apparent decrease. Fresh water was observed to flow down-dip in this system and actually lies beneath the transition zone sodium-calcium bicarbonate groundwater present in overlying beds. Wells that penetrate this zone tend to be flowing artesian, and springs are observed in this interval along Haw Ridge where stream erosion has dissected the ridge. Head pressure derived from this zone may extend down-dip in the Rome Formation beneath the axis of Melton Valley; although deep monitoring data from hydrofracture-associated wells indicate that artesian heads are present, the water is saline in this zone at depth. No estimates have been made of the volume of groundwater flow in this confined zone. The proposed TRU Waste Treatment Facility site is located over the Nolichucky Shale. The Nolichucky Shale outcrops along the southeastern floor of Melton Valley and underlies Melton Branch and lower White Oak Creek and White Oak Lake. The Nolichucky acts as a weak confining unit overlying the Maryville Limestone. In general, the hydraulic head observed in the Nolichucky Shale is consistent with its low topographic position. All factors favor regional groundwater flow parallel to strike toward White Oak Lake and the Clinch River.

3.5.2.2 Site-specific groundwater conceptual model

Flow within the shallow groundwater flow system is generally limited to the uppermost 31 m (100 ft) of saturated regolith, saprolite, and bedrock (DOE 1996a). This area is generally a zone of groundwater discharge, and any contributions to the groundwater from surface sources from the proposed TRU Waste Treatment Facility site could be expected to discharge to either White Oak Creek or Melton Branch. These general points of discharge (White Oak Creek and Melton Branch) are illustrated on the water table map presented as Figure 3-14. Any groundwater recharge at the proposed TRU Waste Treatment Facility site would be expected to remain in the Nolichucky Shale until discharge at the nearby stream(s). In a worst-case scenario, recharge would reach the underlying Maryville Limestone, but even then groundwater would only flow into the more conductive Maryville Limestone in order to more quickly reach the discharge boundary (Melton Branch or White Oak Creek).

Details of the deep groundwater flow system, as outlined previously in the regional conceptual model, generally hold for the deep flow system at the proposed TRU Waste Treatment Facility site. However, at great depth [approximately 305 m (1,000 ft) below ground surface and in the presence of natural brines], waste/grout mixtures were injected by the hydrofracture waste disposal process into the underlying lower Pumpkin Valley Shale. The injected material is suspected to have moved primarily updip, or to the north (DOE 1996a), simultaneously propagating and filling fractures. The hydrofracture waste disposal process resulted in the emplacement of approximately 38,228 m^3 (10.1 million gal) of radioactive wastes and grout containing an aggregate of approximately 1.4 million curies of radioactivity in the 43 grout injections performed between 1959 and 1984. Most of these injections took place at the New Hydrofracture Facility located adjacent to and east of the proposed TRU Waste Treatment Facility site location, or at the Old Hydrofracture Facility located to the northeast across Melton Branch. These waste/grout injection actions are expected to have reduced the permeability of this deep flow system, and consequently limited groundwater flow at this depth. The locations of the Old and New Hydrofracture Facilities, and the anticipated lateral extent of the waste/grout sheets, and of the impacted brine water, are illustrated in Figure 3-15.

3.5.2.3 Groundwater quality

According to the *Remedial Investigation Report on the Melton Valley Watershed at Oak Ridge, Tennessee* (DOE 1997a), the unlined trenches at SWSA 5 North are estimated to contain 14,000 curies and contribute about 6% of the total strontium-90 and 3.6% of the cesium-137 released to surface water in Melton Valley. This rate of release will likely reduce with respect to time because of radioactive decay. The contaminated soils around the underground trenches, and between the trenches

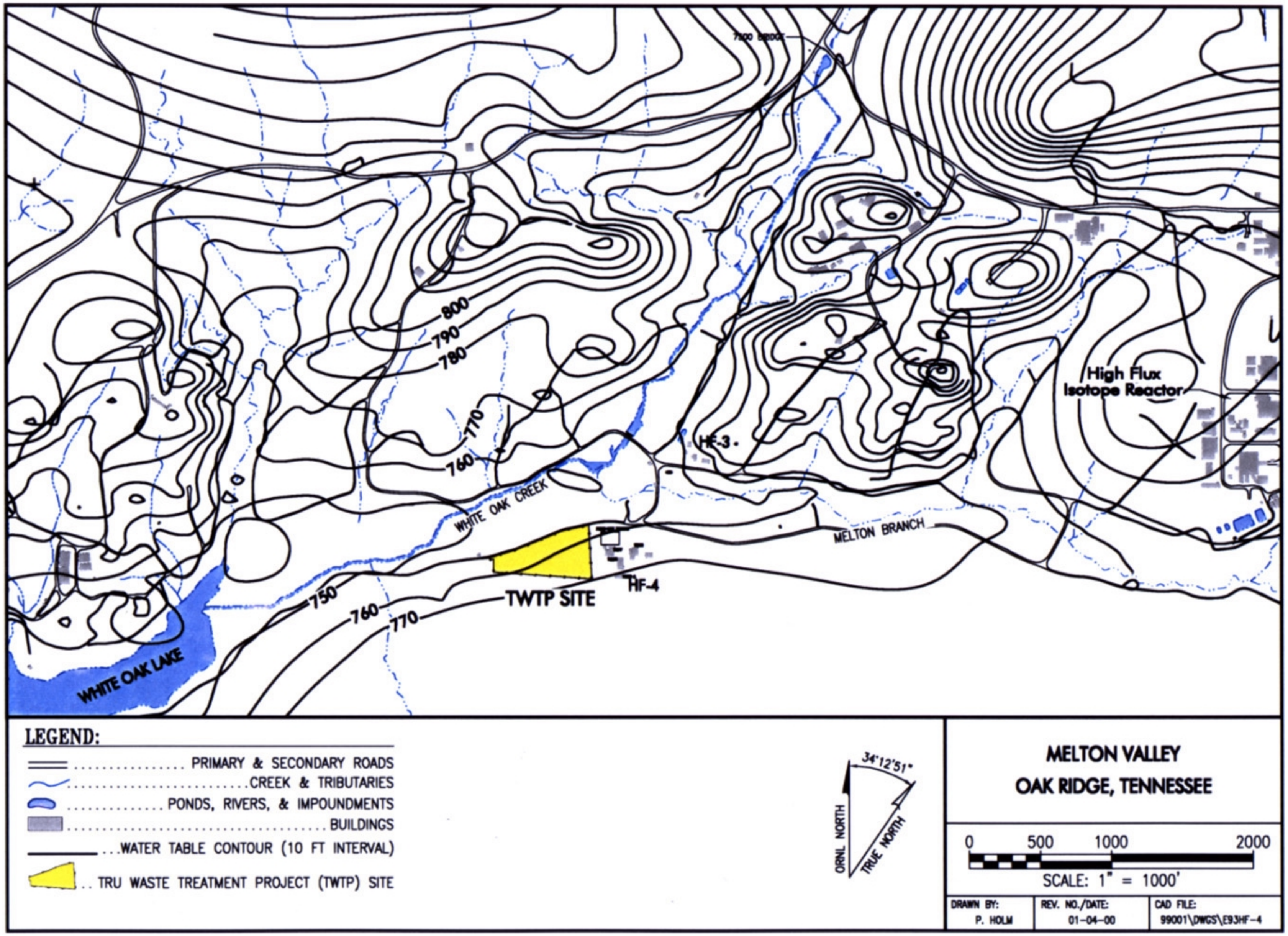


Figure 3-14. Average water table elevation in the Melton Valley Watershed.

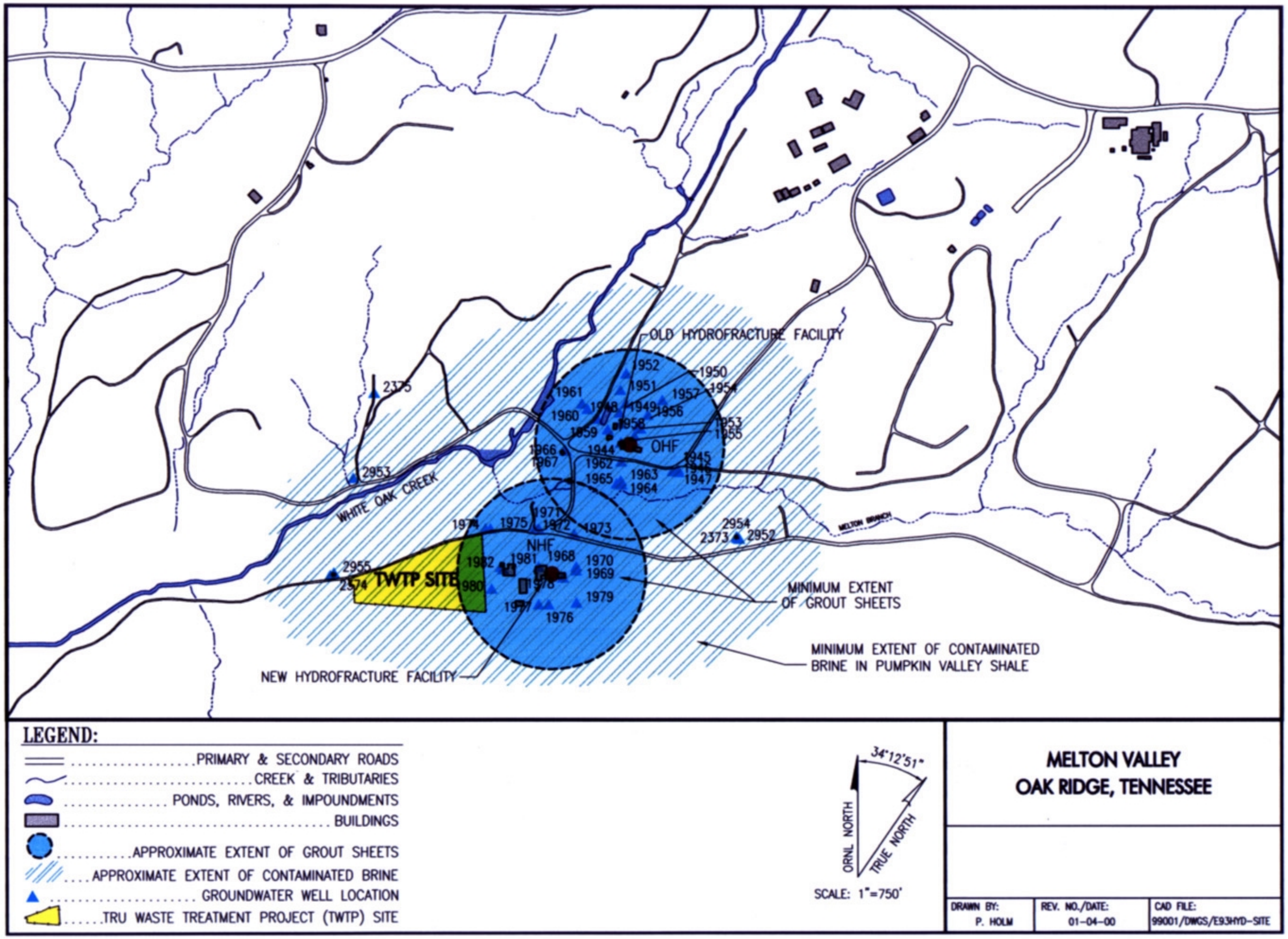


Figure 3-15. Locations of the hydrofracture facility sites, contaminated brine area, injected waste/grout sheets, and groundwater wells.

and White Oak Creek, will also act as a secondary source of contamination to groundwater. Well samples taken adjacent to the SWSA 5 North trenches also showed elevated levels of americium-241 and curium-244 ranging as high as 5,940 pCi/L.

Groundwater quality at the location for the proposed TRU Waste Treatment Facility site must be considered in two separate categories: (1) deep groundwater quality and (2) shallow groundwater quality. The deep groundwater brine approximately 305 m (1,000 ft) below ground surface has been impacted with the radioactive waste injected during the operation of the hydrofracture facilities. However, these past waste disposal processes have done little to impact the shallow groundwater quality. There has been some minor impact to the shallow groundwater as would be expected near a historic industrial facility.

3.5.2.4 Groundwater exit pathways

Shallow groundwater at the proposed TRU Waste Treatment Facility site can be expected to discharge to the north into either Melton Branch or White Oak Creek. Due to the site's close proximity to this regional discharge boundary, it is unlikely that groundwater from the site could discharge anywhere else. A contaminant groundwater discharge point known as "Seep D" is located in the Melton Branch streambed just upstream of the Melton Branch-White Oak Creek confluence. This seep contains high concentrations of strontium-90 and tritium and was part of a previous removal/remedial action. The contaminant source for Seep D is suspected to be groundwater originating in Solid Waste Storage Area 5 and not from the hydrofracture grout sheets. The presence of this seep suggests a good connection with the underlying Nolichucky Shale.

3.5.3 Wetlands and Floodplains

There are six wetlands within 0.8 km (0.5 mile) of the proposed TRU Waste Treatment Facility site, herein labeled as Wetlands A, B, C, D, E, and F (Figure 3-16). The wetlands were identified using three sources of information, including: (1) a report on wetland delineation on the proposed TRU Waste Treatment Facility site (Jacobs and Rosensteel 1999); (2) an on-site reconnaissance by wetland scientists from SAIC on June 2, 1999; and (3) review of National Wetland Inventory maps. The six wetlands are briefly described below. A wetlands assessment was also performed (Appendix C.6).

Jacobs and Rosensteel (1999) identified and delineated four small wetlands (Wetlands A, B, C, and D) on, or adjacent to, the TRU Waste Treatment Facility site (Figure 3-16). A copy of the report, which contains detailed descriptions of the wetlands along with copies of the field data sheets, is presented in Appendix C.1. Wetlands A, B, and C were delineated during the field survey of the TRU Waste Treatment Facility site on April 20, 1999. Wetland D was initially identified in April 1992 by B. Rosensteel and was not delineated again. Wetland A is approximately 0.146 ha (0.36 acres) and is located approximately 91 m (298 ft) south of the southwest corner of the TRU Waste Treatment Facility site (Figure 3-16). It is a saturated, temporarily flooded, palustrine emergent wetland in an intermittent stream drainage. The stream originates upslope near the base of Copper Ridge and flows through a clearing where the wetland has developed around seeps that contribute to the stream flow. Soil samples from several locations in the wetland had low chroma color matrix, mottles, and oxidized rhizopheres (root channels). Dominant vegetation at Wetland A included several obligate species [sweetflag (*Acorus calamus*), black willow (*Salix nigra*), monkey flower (*Mimulus ringens*), bugleweed (*Lycopus virginicus*), and cattail (*Typha latifolia*)], as well as several faculative wet species [soft rush (*Juncus effusus*), silky dogwood (*Cornus amomum*), boxelder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), and turnflower rush (*Juncus biflorus)*].

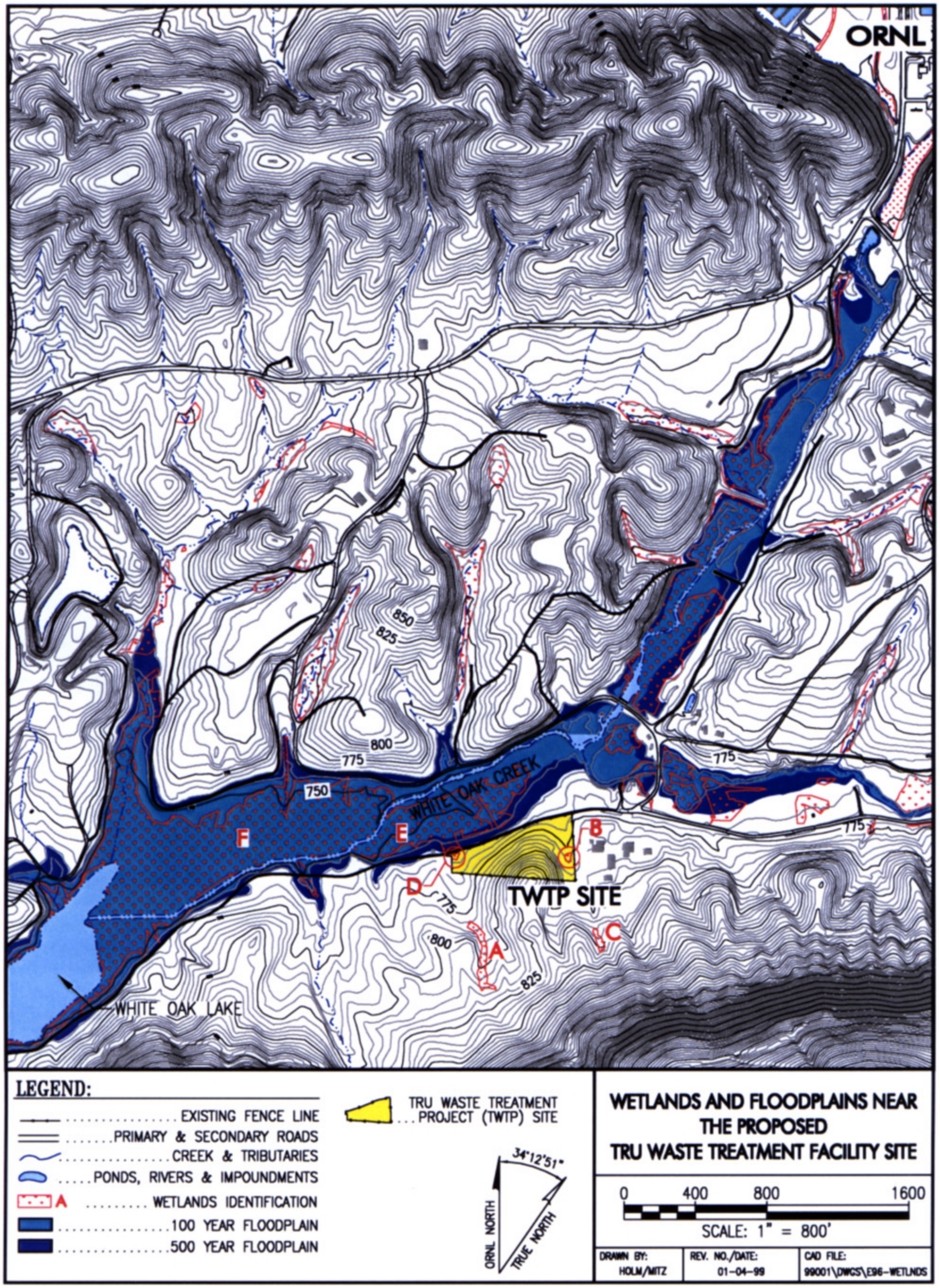


Figure 3-16. Wetlands, 100-, and 500-year floodplains near the proposed TRU Waste Treatment Facility site.

Wetland B is only 0.012 ha (0.03 acres) and is located in an intermittent stream along the eastern side of the proposed TRU Waste Treatment Facility site (Figure 3-16). This wetland is temporarily flooded and saturated and is palustrine scrub-shrub (Jacobs and Rosensteel 1999). An old road-crossing culvert located downstream from the site acts to slow and retain stream flow, thereby causing the riparian zone saturation at the wetland. The soil included fine gravel alluvium and silt loam with low chroma matrix, mottles, and partially decomposed plant fragments. Dominant plant species include sweetgum (*Liquidambar styraciflua*), green ash saplings, silky dogwood, sedges (*Carex* spp. and *Scirpus* spp.), sweetflag, and meadow spike-moss (*Selaginella apoda*).

Wetland C is 0.036 ha (0.09 acres) and is located approximately 91 m (298 ft) south of the proposed TRU Waste Treatment Facility site's southeast corner (Figure 3-16). Wetland C is saturated, palustrine emergent, and located in a disturbed, grassy area upslope (Jacobs and Rosensteel 1999). Wetland C is periodically mowed, so the wetland is in a topographic low area that might have contained a section of intermittent stream prior to land disturbance and hydrological alterations. Water discharges from seeps in the wetland and then re-enters the ground at the downslope end of the wetland.

Wetland D is 0.016 ha (0.04 acres) and is located in the northwest corner of the proposed TRU Waste Treatment Facility site (Figure 3-16). This wetland is a saturated, emergent wetland. The wetland has developed in a seep area, but there is wetland hydrology due to slowing of the water flow by a culvert under the Old Melton Valley Road. Standing and flowing water were present in the wetland during the April 1999 site visit. The soil matrix color during the initial delineation in April 1992 was described as dark gray (per Munsell soil color charts) and grayish brown, with strong brown, and very dark gray mottles. Dominant plant species identified in the April 1992 survey included several obligate species such as black willow, soft rush, monkey flower, cattail, fox sedge (*Carex vulpinoidea*), shallow sedge (*Carex lurida*), and rice cutgrass (*Leersia oryzoides*).

Wetland E includes most of the floodplain of Melton Branch north of the Old Melton Valley Road along the northern perimeter of the proposed TRU Waste Treatment Facility (Figure 3-16). This wetland covers several hectares (acres). Because of potential radiological contamination of the floodplain soils, walkover and intrusive sampling of the floodplain area were not performed. This wetland was identified from National Wetland Inventory maps, which depict the area as palustrine forested wetland dominated by broad-leaved deciduous trees. Dominant plant species include boxelder, sycamore (*Platanus occidentalis*), and black willow.

Wetland F includes the shoreline and upper reaches of White Oak Lake and covers several hectares (Figure 3-16). National Wetland Inventory maps depict this area as lacustrine wetland. The shoreline includes a mixture of trees, shrubs, and persistent and nonpersistent wetland plants.

The proposed TRU Waste Treatment Facility site is not within a floodplain. The 100-year and 500-year floodplains associated with White Oak Creek are immediately north of the proposed site location, with the 500-year floodplain bordering the Old Melton Valley Road (Figure 3-16).

3.6 WASTE MANAGEMENT

The estimated waste volumes associated with the CERCLA cleanup actions for the ORR range between 170,495 m^3 and 841,005 m^3 (223,000 to 1.1 million yd^3) (DOE 1999b). In addition to the existing legacy TRU waste at ORNL, stored in the Melton Valley Storage Tanks and various storage buildings and bunkers, an additional 3,500 m^3 (4,578 yd^3) of TRU wastes are expected to be generated over the life cycle of operations (DOE 1998b). Approximately 41,000 m^3 (53,624 yd^3) of mixed low-level waste are currently in the DOE ORR inventory, and nearly 31 million cubic meters (40.5 million yd^3) are expected to be generated over the life cycle of operations (DOE 1998b). After undergoing a range of treatments, approximately 16 million cubic meters (20.9 million yd^3) of treated effluent will be discharged under an NPDES permit (DOE 1998b). The existing legacy liquid, sludge and solid wastes, and waste storage facilities at ORNL are described in Chapter 1, Section 1.2.2. Recent historical and projected generation rates for remote-handled TRU and contact-handled TRU debris are shown in Table 3-12.

Table 3-12. Historical and projected remote-handled TRU and contact-handled TRU debris generation rates at ORNL

Waste	FY 1997	FY 1998	FY 1999	FY 2000
Remote-handled TRU	5.0 m^3	6.6 m^3	6.6 m^3	5.0 m^3
Contact-handled TRU	12.2 m^3	23.6 m^3	7.5 m^3	10.0 m^3

FY = fiscal year.
ORNL = Oak Ridge National Laboratory.
TRU = transuranic.
Source: Bechtel Jacobs (1999).

Remote-handled TRU sludge will no longer be generated after Fiscal Year 2000 due to the completion of the ORNL inactive tank wastes retrieval projects, but approximately 5.5 m^3 of TRU waste are projected to be generated annually at the Radiological Engineering Development Center at ORNL. Pretreatment of this newly generated waste is expected to be conducted in the Radiological Engineering Development Center hot cells beginning in Fiscal Year 2001 and will be an ongoing operation at the facility. Thus, over 20 m^3 of TRU waste per year is projected to be generated at ORNL. Low-level waste generation is estimated at approximately 60 m^3 per year (Scott 1999).

3.7 CLIMATE AND AIR QUALITY

3.7.1 Climate

The Oak Ridge area has a temperate, continental climate. Summers are warm and humid; winters are typically cool. Spring and fall are transitional seasons, normally warm and sunny. Severe weather—such as tornadoes or high winds, severe thunderstorms with damaging lightning or precipitation, extreme temperatures, or heavy precipitation—is uncommon. The Cumberland Mountains to the northwest help to shield the region from cold air masses that frequently penetrate far south over the plains and prairies in the central United States during winter months. During the summer, tropical air masses from the south provide warm and humid conditions that often produce thunderstorms; however, anticyclonic circulation around high-pressure systems centered in the western Gulf of Mexico can bring dry air from the southwest into the region, leading to periods of drought.

3.7.1.1 Temperature

Over the period from January 1990 through December 1996, the mean annual temperature for the Oak Ridge area was 14.6°C (58.3°F) (NOAA 1997). The coldest month is usually January, with temperatures averaging about 3.7°C (38.7°F). July is usually the hottest month of the year, with temperatures averaging 25.8°C (78.4°F).

3.7.1.2 Wind

Winds in the Oak Ridge area are controlled, in large part, by the Valley and Ridge topography. Prevailing winds are either up-valley (northeasterly) daytime winds or down-valley (southwesterly) nighttime winds. Wind speeds are less than 11.9 km/hour (7.4 mph) 75% of the time; tornadoes and winds exceeding 30 km/hour (18.5 mph) are rare. Air stagnation is relatively common in eastern Tennessee (about twice that of western Tennessee). An average of about two multiple-day air stagnation episodes occurs annually in eastern Tennessee, to cover an average of about 8 days/year. August, September, and October are the most likely months for air stagnation episodes. Figure 3-17 presents the diurnal wind patterns for the ORR.

3.7.1.3 Precipitation

The 30-year annual average precipitation is 138.5 cm (54.5 in.), including about 24 cm (9.3 in.) of snowfall (NOAA 1997). Regional precipitation for the period 1990–96 was 149.1 cm (58.7 in.) with a maximum of 169 cm (66.5 in) in 1995 and a minimum of 111.8 cm (44 in.) in 1992. Precipitation in the region is greatest in the winter months (December through February). Precipitation in the spring exceeds the summer rainfall, but the summer rainfall may be locally heavy because of thunderstorm activity. The driest periods generally occur during the fall months, when high-pressure systems are most frequent.

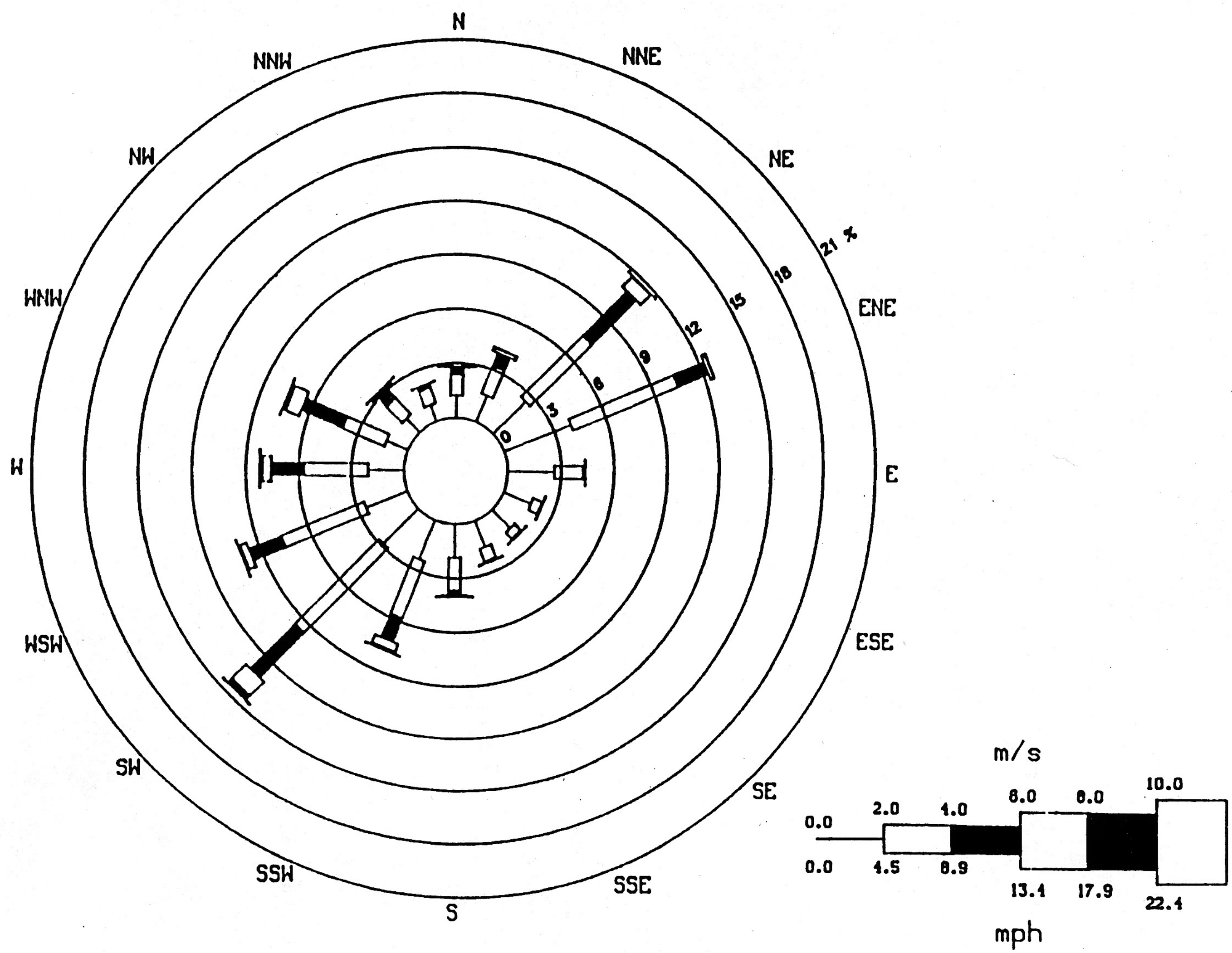
3.7.2 Air Quality

The proposed TRU Waste Treatment Facility site is located in the EPA Air Quality Control Region 207, which includes east Tennessee and southwest Virginia. As of 1991, the Air Quality Control Region was designated as an attainment area with respect to all National Ambient Air Quality Standards (NAAQS) criteria pollutants (ORNL 1998). The Oak Ridge area also is an attainment area with respect to NAAQS for all criteria pollutants (SO_2, particulate matter, NO_2, CO, ozone, and Pb) (ORNL 1998). ORR and ORNL sources are in compliance with all federal air regulations and TDEC air-permit requirements for non-radioactive hazardous air pollutants (Table 3-13).

The ORR is located within a Class II prevention-of-significant deterioration (PSD) area. The Great Smoky Mountains National Park is the only PSD Class I area in the vicinity of ORNL, and it is located approximately 35 miles (56 km) southeast of ORR. All areas not designated as Class I PSD areas are designated as Class II. No PSD permits have been required for any emissions source at ORNL since the promulgation of the regulations.

Air monitoring at the DOE Oak Ridge installations consists of both facility exhaust stack and ambient air monitoring adjacent to the facilities to measure radiological parameters (Table 3-14). Ambient air monitoring allows facility personnel to determine the relative level of contaminants at the monitoring locations during an emergency, measures the contributions of fugitive and diffuse sources, and permits checks on dose-modeling calculations. There are four ambient air monitoring stations in the ORNL network. Station 1 is west, southwest of ORNL; station 2 is southeast of ORNL; station 3 is on the northeast corner of the ORNL site; and station 7 is nearly on the northwest corner of ORNL (Table 3-14). Station 52 is a reference station located at Fort Loudon Dam, approximately 16 km (10 miles) from ORNL. Sampling is conducted at each station to measure absorbable gases (e.g., iodine), and gross alpha, gross beta, and gamma-emitting radionuclides, and then compared with air sampling data from the reference station (station 52).

WIND ROSE ORNL tower MT2 (@100m) for 1991–1995



Adapted from 1996 ORNL Permit Application for TRU and Class III/IV Storage Areas (TNHW-097).

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Figure 3-17. Wind rose detected at the ORNL Tower MT2 (@ 100 m) for 1991–1995.

Table 3-13. Summary of 1997 air monitoring data in the vicinity of the ORR

Pollutant/averaging time	Nearest monitor location	Maximum per quarter 1st	2nd	3rd	4th	NAAQS TAAQS	Number of exceedances
Particulate Matter-10/24 hours	Knox Co.	69.0 μg/m^3	67.0	61.0	60.0	150 μg/m^3	0
Particulate Matter-10/annual	Knox Co.	33.0 μg/m^3				50 μg/m^3	0
Total Suspended Particles/24 hours	Knox Co.	107.0 μg/m^3	87.0	77.0	77.0	260.0 μg/m^3[a]	0
Ozone/1 hour	Anderson Co.	0.109 ppm	0.107	0.106	0.105	0.12 ppm	0
Nitrogen Oxide/annual	Loudon Co.	0.015 ppm				0.05 ppm	0
Sulfur Dioxide/3 hours	Anderson Co.	0.152 ppm	0.125			0.5 ppm	0
Sulfur Dioxide/24 hours	Anderson Co.	0.032 ppm	0.025			0.14 ppm	0
Sulfur Dioxide/annual	Anderson Co.	0.005 ppm				0.03 ppm	0
Carbon Monoxide/1 hour	Knox Co.[b]	10.3 ppm	9.6			35.0 ppm	0
Carbon Monoxide/8 hours	Knox Co.[b]	4.9 ppm	4.8			9.0 ppm	0
Lead/quarterly	Roane Co.[c]	0.13 μg/m^3	0.11	0.07		1.5 μg/m^3	0

[a]260.0 μg/m^3 primary standard, 150.0 μg/m^3 secondary standard for total suspended particulates (TSP).
NAAQS -National Ambient Air Quality Standards.
[b]Lead measurements taken from Rockwood, Tennessee.
[c]Carbon monoxide data taken from Knoxville, Tennessee.
ORR - Oak Ridge Reservation.
ppm - parts per million.
TAAQS - Tennessee Ambient Air Quality Standards.
μg - micrograms.
Source: DOE 1999a. Final EIS for Construction and Operation of the Spallation Neutron Source.

Table 3-14. Radionuclide parameter concentrations and other parameters measured at ORNL air monitoring stations, 1997

Parameter	Stations 1 (μCi/mL)	2 (μCi/mL)	3 (μCi/mL)	7 (μCi/mL)	52[a] (μCi/mL)
Beryllium-7	1.6E-14	1.0 E-14	9.8E-15	9.9E-15	1.6E-14
Cesium-137	3.1E-17	2.0E-17	5.2E-17	2.1E-17	2.3E-17
Cobalt-60	3.0E-17	ND	1.6E-17	ND	1.1E-17
Hydrogen-3	ND	7.8E-11	ND	2.6E-12	ND
Iodine-131	8.5E-16	1.5E-15	2.4E-15	9.4E-16	NA
Iodine-133	ND	2.3E-15	2.6E-15	3.7E-15	NA
Iodine-135	7.5E-15	5.6E-14	1.5E-14	ND	NA
Potassium-40	8.3E-16	9.1E-16	1.2E-15	9.3E-16	2.3E-15
Uranium-234	3.0E-17	3.6E-17	2.9E-17	4.0E-17	4.1E-17
Uranium-235	3.5E-18	ND	ND	ND	3.6E-18
Uranium-238	2.9E-17	2.6E-17	3.3E-17	3.0E-17	3.7E-17
Gross alpha	5.3E-15	4.5E-15	4.2E-15	6.3E-15	
Gross beta	1.1E-14	1.1E-14	1.0E-14	1.1E-14	

[a]Reference station located at Fort Loudon Dam.
NA = not available. ND = not detected. ORNL = Oak Ridge National Laboratory.
Source: Adapted from ORNL 1998.

3.7.2.1 Clean Air Act

Authority for enforcement of the Clean Air Act (CAA) is shared between the TDEC for nonradioactive emission sources, and the EPA for radioactive emission sources. The EPA also enforces rules issued pursuant to the 1990 CAA Amendments, Title VI - Stratospheric Ozone Protection. The TDEC Air Permit Program ensures compliance with most of the federal CAA and TDEC rules for air emission sources.

There are a number of sources at ORNL that are exempt from the permitting requirements under the State of Tennessee rules. At the end of Calendar Year 1997, ORNL had 21 active TDEC-issued operating permits covering 250 sources.

3.7.2.2 National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad-NESHAPs)

All ORNL facilities met the emissions and test procedures found at 40 *CFR* 61, Subpart H, in 1997. Operations at ORNL are in compliance with all Federal and State air regulations and TDEC air permit requirements. In addition, continuous air monitoring is conducted at seven stacks at ORNL (Table 3-14).

The ORR facilities were in compliance with the National Emission Standards for Hazardous Air Pollutants for Radionuclides (RAD-NESHAPs) dose limit of 10 mrems/year to the maximally exposed individual of the public during 1997 (Table 3-14). Based on modeling of emissions from major and minor sources, the effective dose equivalent was 0.41 mrem/year in 1997.

3.8 TRANSPORTATION

Section 3.8.1 addresses local transportation routes, ongoing and planned road upgrade, and waste shipment information. In Section 3.8.2, national transportation routes and waste shipment data are provided as baseline information.

3.8.1 Local Transportation

Transportation in the region in and immediately adjacent to the ORR boundary consists of local access roads (such as Tennessee State Routes 95, 1700, and 62) and major interstates. The main access to the cities of Nashville and Knoxville, Tennessee, is provided by I-40, located 2.4 km (1.5 miles) south of the ORR boundary and 8 km (5 miles) from the proposed TRU Waste Treatment Facility site. The major interstate running north and south is provided by I-75, located 24 km (15 miles) south of the proposed TRU Waste Treatment Facility site. Railroad service is provided by the Southern Railway and the L&N Railway. An L&N rail line runs adjacent to the proposed TRU Waste Treatment Facility site boundary.

Transportation elements include the number of rail and truck shipments to and from the DOE sites. According to the 1993 Shipment Mobility/Accountability Collection and the Waste Manifest System for Fiscal Year 1993, ORR had 197 incoming radioactive truck shipments with a total weight of 175,662 kg (387,269 lbs), and 843 outgoing radioactive truck shipments weighing 10,496,492 kg (23,140,823 lbs). There were also 8 outgoing radioactive rail shipments totaling 451,623 kg (995,658 lbs). This shipment information includes all radioactive material, not just radioactive waste. In 1998, a total of 3,080 m^3 (108,825 ft^3) of waste was shipped from the ORR to a commercial facility (EnviroCare) in Utah without incident.

The Old Melton Valley Road begins near the south end of White Oak Dam on the east side of Tennessee State Route 95 and continues east along the north side of the proposed TRU Waste Treatment Facility site. DOE prepared a categorical exclusion (CX-TRU-98-007) for the upgrade of this road (Appendix G). Scheduled road improvements at the intersection of Tennessee State Route 95 and the Old Melton Valley Road will accommodate Tennessee Department of Transportation sight distance and other technical requirements. The Tennessee Department of Transportation reported that 6,140 vehicles used Tennessee State Route 95 in 1998. A portion of Tennessee State Highway 58, located west of the ETTP, is scheduled to be upgraded to four lanes in the near future. Tennessee State Route 62 leading into the City of Oak Ridge, from Knoxville, bordering the ORR on the east side, is currently being upgraded.

3.8.2 National Transportation

Transportation of hazardous and radioactive materials, substances, and wastes is governed by DOT, NRC, and EPA regulations, and by the Hazardous Materials Transportation Act. These regulations are found in 49 *CFR* Parts 171-178, 49 *CFR* Parts 383-397, 10 *CFR* Part 71, and 40 *CFR* Parts 262 and 265.

Transportation mode and routing analyses were presented by DOE for TRU wastes in both the *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (WIPP SEIS-II) (DOE 1997b) and the *Final Waste Management Programmatic Environmental Imaact Statement* (WM PEIS) (DOE 1997c). These documents established the national transportation environment in terms of the applicable government regulations and DOE policy related to transporting radiological and hazardous material, general risk criteria, and the methodology for determining national transportation routes. Transportation routes described in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997c) were derived from the HIGHWAY program model and the INTERLINE model, which consider population densities along the routes. These routes are depicted in the following figures: Figure 3-18 describes the TRU waste route to the Waste Isolation Pilot Plant, and the low-level waste route to the Nevada Test Site is described in Figure 3-19.

Waste Transportation Route from the Oak Ridge National Laboratory (ORNL) to the Waste Isolation Pilot Plant (WIPP)

Figure 3-18. Transportation route from the ORNL in east Tennessee to the Waste Isolation Pilot Plant in southeast New Mexico.

Waste Transportation Route from the Oak Ridge National Laboratory (ORNL) to the Nevada Test Site (NTS)

Figure 3-19. Transportation route from the ORNL in east Tennessee to the Nevada Test Site.

TRU waste route description (Waste Isolation Pilot Plant SEIS-II Fact Sheet) (DOE 1999c)

Old Melton Valley Road west to Tennessee State Route 95, west of ORNL
Tennessee State Route 95 south to I-40 south of Oak Ridge, Tennessee
I-40 east to I-75, southwest of Knoxville, Tennessee
I-75 south to I-24, east of Chattanooga, Tennessee
I-24 west to I-59, southwest of Chattanooga, Tennessee
I-59 to I-459, northeast of Birmingham, Alabama
I-459 to I-20, southwest of Birmingham, Alabama
I-20 west to I-220, east of Shreveport, Louisiana
I-220 to I-20, around the north side of Shreveport, Louisiana
I-20 west to US-285, at Pecos, Texas
US-285 to US-180/62, at Carlsbad, New Mexico
US-180/62 to the Waste Isolation Pilot Plant, North Access Road
Waste Isolation Pilot Plant, North Access Road

Low-level waste route description (ORNL Transportation Work Instructions) (LMES 1995b)

Old Melton Valley Road west to Tennessee State Route 95, west of ORNL
Tennessee State Route 95 south to I-40, south of Oak Ridge, Tennessee
Continue on I-40, west to U.S-95, north of Needles, California
U.S-95 north to Mercury, Nevada

On the national level, about 100 million packages, classified as hazardous materials, are shipped each year (NRC 1997). A more recent radioactive materials transport study stated that, excluding DOE shipments, approximately 2 million shipments of radioactive materials consisting of 2.79 million packages are made each year (DOE 1997a). For more than 40 years, radioactive materials have been shipped in the United States with no known adverse health effects due to accidental releases. Information about accidents involving radioactive materials has been collected over a 23-year period. During that period, 349 air, highway, and rail transportation accidents occurred. Of these accidents, 307 were highway, 20 were rail related, and the remaining 22 were air related. Packages used for shipping quantities or types of radioactive materials, which could have serious consequences if released, are designed to withstand accident conditions. Accidents involving these packages have resulted in no release of radioactive material. The NRC has concluded that at least half of the radiation exposure resulting from shipments of radiological materials would be received by transportation workers, but the doses would be below allowable limits (DOE 1997a).

3.9 UTILITY REQUIREMENTS

The Tennessee Valley Authority (TVA) supplies power to the ORR, which has a current site load of 116 MW. Coal and natural gas are also used (DOE 1997b), although no gas pipeline exists in the vicinity of the proposed TRU Waste Treatment Facility site. Water is supplied to ORNL by the City of Oak Ridge Water Treatment Facility located on Pine Ridge in the northeastern portion of the ORR. This facility draws water from the Clinch River (near the Y-12 Plant, upriver from ORNL) and provides approximately 1.2 million gal per day to ORNL, 4.0 million gal per day to Y-12, and 8.8 million gal per day to the City of Oak Ridge. The facility is currently operating at approximately 50% of its 28 million gal per day capacity (McWilliams 1999).

3.10 HUMAN HEALTH

This section contains an overview of the potentially affected environment on and around the ORR and discusses the potential exposure pathways, and cites pertinent references concerning population exposure and its effects. This information has been used to evaluate the impacts and potential risks to the off-site maximally exposed individual and the collective dose to the population within 80 km (50 miles) from current ORR operations.

3.10.1 Exposure Pathways

The analyzed human exposure pathways included in this EIS are inhalation, direct radiation, ingestion, and direct contact. A primary exposure pathway is inhalation of contaminants from stack emissions. Radiological airborne effluents from ORNL consist mainly of ventilation air from radioactively contaminated areas and ventilation from reactor facilities. These discharges are treated and pass through HEPA filters before being released to the environment. NESHAPs regulations and DOE orders define a major radionuclide effluent source as an emission point that has the potential to discharge radionuclides in quantities that could result in an effective dose equivalent of 0.1 mrem or more to the public. ORR has a comprehensive air monitoring program to ensure regulatory compliance. Four exhaust stacks located in the Bethel and Melton valleys at ORNL are major radionuclide emission point sources. In 1997, ORNL had 21 minor sources, 3 of which were continuously sampled (ORNL 1998). In 1997, ORNL released approximately 148 curies of hydrogen-3 and 0.55 curies of iodine-131. The major contributor to off-site dose in 1997 was argon-141, of which 10,000 curies were released (ORNL 1998). In addition to exhaust stack monitoring, ambient air monitoring is performed to directly measure the airborne concentrations of radionuclides and pollutants at the site perimeter. Reference data are collected from a remote location not affected by activities at the ORR. Airborne radionuclides and airborne chemicals and their effects on the population within the Region of Influence are discussed in Sections 3.10.2.1 and 3.10.3.1, respectively.

Direct radiation is also an exposure pathway of concern. External gamma radiation measurements are recorded weekly at the ORR boundary to ensure that radioactive effluents from the ORR are not increasing external radiation levels significantly above background radiation levels. Direct radiation, and its effects on the nearby population, is discussed in Section 3.10.2.4. Another exposure pathway is the ingestion of contaminated vegetation and animal products produced in the surrounding areas. Samples of food that could be potentially contaminated are collected and analyzed to determine their effects and potential exposure through ingestion. This information is presented in Section 3.10.2.2

Additional exposure pathways include contact with contaminated surface water and drinking contaminated groundwater. Under the ORR Environmental Monitoring Plan, samples are collected and analyzed from 22 locations around the ORR to determine the quality of local surface water. Surface water at ORNL is collected downstream from the facility and compared to the surface water at reference locations. The water is analyzed for radionuclides and inorganic pollutants. Most residents in the Oak Ridge area do not rely on groundwater for potable supplies. Local groundwater provides some potable, domestic, municipal, farm, irrigation, and industrial uses. DOE samples residential wells in the area. These nearby residential wells are located across the Clinch River, and are hydrologically separate from the Melton Valley Watershed. Storm water and most groundwater at ORR discharge at surfacce water drainages. Therefore, monitoring springs, seeps, and surface water quality is a way to assess the extent to which groundwater from a large portion of the ORR transports contaminants. The groundwater monitoring program at ORNL consists of a network of two types of wells: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes, and (2) piezometer wells used to characterize groundwater flow conditions.

Melton Valley is one of the major waste storage areas on the reservation. In addition to surface structures, it is the location of shallow waste burial trenches and auger holes, landfills, tanks, impoundments, seepage pits, hydrofracture wells and grout sheets, and waste transfer pipelines and associated leak sites, all of which can affect the groundwater of the region. Groundwater plumes within Melton Valley generally enter the surface water system where contaminants may be encountered. Information on the affected population due to surface water and groundwater exposure is presented in Section 3.10.3.3.

3.10.2 Pathway Modeling

Risks from the ORR operations are calculated for the maximally exposed off-site individual and the collective off-site population. The off-site population is defined as the public within 80 km (50 miles) of the ORR (ORNL 1995). The computer software program CAP-88 was used to perform the radiological dose and risk assessments for the collective off-site population and the maximally exposed off-site individual from radionuclides released into the atmosphere from ORR operations. Small quantities of chemicals are released into the atmosphere due to operations at ORR. These chemical releases are allowable under air pollution controls and are not a threat to human health. Therefore, chemical modeling is not required (ORNL 1998).

The radiological consequences from airborne contaminants are calculated using the CAP-88 program, which is a package of computer codes (contains the EPA-approved version of the AIRDOS and DARTAB) designed to demonstrate compliance with the Rad-NESHAPs, 40 *CFR* 61, Subpart H. CAP-88 is only applicable for chronic low-level exposures and is not appropriate for modeling short-term or accidental releases. The program uses a Gaussian plume equation to determine the average dispersion of radionuclides emitted from a source or stack. This model assumes that an effluent is released from a point source and is normally distributed around the central axis of the plume. It is also assumed that the atmospheric stability and wind speed determine how the contaminant is dispersed downwind from the source. Uneven terrain and fluctuations in meteorological conditions contribute to the uncertainty of the model. The CAP 88 program also models the ingestion and immersion pathways and determines the radionuclide concentrations in air and rates of deposition on ground surfaces. The concentrations in food, and intake rates to people from ingestion of vegetation and animal products in the affected area, are calculated by using Regulatory Guide 1.109 (NRC 1997) food-chain models. Radionuclide concentrations are estimated for produce, leafy vegetables, milk, and meat. Total dose and risk estimates are then calculated by combining the inhalation and ingestion intake rates with the air and ground surface concentrations. Risks are based on a lifetime risk of 5E-04 cancers per rem (risk of cancer in a lifetime is 5 in 10,000 individuals per rem of exposure) (DOE 1997d).

3.10.3 Radionuclides

3.10.3.1 Airborne Radionuclides

In 1997, 42 emission points on the ORR were modeled with CAP-88, including 25 points at ORNL, in order to estimate the effective dose equivalent to the off-site maximally exposed individual and the collective effective dose equivalent to persons residing within 80 km (50 miles) of the ORR. The effective dose equivalent calculations are conservative, and it is assumed that each person remained outside of the house, unprotected for the entire year. It was also assumed that 70% of the vegetables and produce, 44.2% of the meat, and 39.9% of the milk consumed by each individual were produced locally (e.g., a home garden). It was assumed that the remaining portion of food was produced within 80 km (50 miles) of the ORR (ORNL 1998).

The effective dose equivalent received by the off-site maximally exposed individual from airborne emissions was estimated to be 0.41 mrem for the ORR and 0.38 mrem for ORNL. This corresponds to a fatal cancer risk of 2E-07 for each of the effective dose equivalents, and can be calculated by multiplying the effective dose equivalent by the probability of an individual dying of cancer (4.1E-04 rem × 5E-04/rem). The fatal cancer risk for the general public is 5E-04/rem based on International Commission on Radiological Protection (ICRP) Publication No. 60 (ICRP 1991). The NESHAPs standard is 10 mrem, so the risk associated with these doses is minimal. In perspective, the average person receives approximately 300 mrem annually from natural background radiation. The collective effective dose equivalent to the affected population, about 879,546 persons, within 80 km (50 miles) was estimated to be 10 person-rem. This corresponds to a fatal cancer risk of 5E-03. A person-rem is the collective dose to a population group; for example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem. Emissions from ORNL contributed about 58% of the ORR collective effective dose equivalent, or about 5.8 person-rem, which corresponds to a calculated cancer risk of 3E-03. The estimated doses to the off-site maximally exposed individual and the affected population are shown in Table 3-15 (ORNL 1998).

Table 3-15. Calculated effective dose equivalent to the maximally exposed individual and the collective population effective dose equivalent from airborne releases in 1997

Location	Effective dose equivalent to a maximally exposed individual (mrem)	Fatal cancer risk to a maximally exposed individual	Collective population effective dose equivalent (person-rem)	Fatal cancer risk to collective population
ORNL	0.38	2E-07	5.8	5E-03
ORR	0.41	2E-07	10.0	3E-03

ORNL - Oak Ridge National Laboratory.
ORR - Oak Ridge Reservation.

These estimated doses were compared to the dose calculated from measured air concentrations of radionuclides at monitoring stations located at the ORR perimeter and remote locations. A hypothetical individual residing at the perimeter in 1997 could have received an effective dose equivalent from 0.11 to 0.32 mrem, which would result in a calculated fatal cancer risk of 6E-08 and 2E-07, respectively. This dose would include contributions from naturally occurring airborne radionuclides, radionuclides released from the ORR, and radionuclides released from any other non-DOE source. Other potential sources of radioactive emissions include a waste processing facility, a depleted uranium processing facility, a decontamination facility in Oak Ridge, and a waste processing facility in Kingston. A hypothetical person residing at the remote monitoring location would have received an effective dose equivalent of 0.13 mrem (ORNL 1998), which corresponds to a fatal cancer risk of 7E-08.

3.10.3.2 Radionuclides in food

Samples of hay, tomatoes, lettuce, turnips, milk, and fish are collected and analyzed to determine potential exposure through ingestion. The CAP-88 program was used to determine radiation doses from the ingestion of meat, milk, and vegetables due to the deposition of radionuclides from the ORR. A total of 5.3 mrem was calculated for the maximally exposed individual from all sources, which are discussed below. When compared to the average annual background radiation for individuals of 300 mrem the risk associated with the ingestion is small.

The milk sampling program in 1997 consisted of grab samples collected every other month from three locations near the ORR. The milk samples are analyzed at ORNL for iodine-131, potassium-40, total strontium (strontium-89 and strontium-90), and hydrogen-3, all of which are found in the natural environment. Only strontium and potassium-40 were detected in the milk, and potassium-40 is not emitted from the ORR. It was assumed that if a hypothetical person drank 310 liters (328 quarts) of this milk during the year, the individual would receive an effective dose equivalent between 0.66 and 1.5 mrem (ORNL 1998), which corresponds to a hypothetical cancer risk of 3E-07 and 8E-07, respectively. Hay samples were cut from six areas in 1997, and an additional site, near Fort Loudon, was used as a reference site. The samples were analyzed for gross alpha and beta, and gamma emitters. Composite samples (from areas 1, 2, and 3, and areas 2, 4, and 5) had statistically significant results for cesium-137, gross beta, and beryllium-7. The two individual locations, area 6 and area 8 (the reference location), had statistically significant results for gross beta and beryllium-7. Beryllium-7 is a naturally occurring isotope. There were no other statistically significant radiological results in the 1997 hay samples.

Tomatoes, lettuce, and turnips were purchased from five farmers near the ORR in 1997. These vegetables represent the fruit-bearing, leafy, and root vegetables. The sampled locations were chosen based on availability and the likelihood of the produce being affected by routine operations on the ORR. A hypothetical person was assumed to have eaten 32 kg (71 lbs) of homegrown tomatoes, 10 kg (22 lbs) of homegrown leafy vegetables, and 37 kg (82 lbs) of homegrown root vegetables during the year. This would result in a conservative total effective dose equivalent of 3.4 mrem, practically all of which results from potassium-40, which is a naturally occurring radionuclide and is not emitted from the ORR. If potassium-40 is excluded, this hypothetical person would receive about 0.008 mrem (ORNL 1998), which corresponds to a calculated cancer risk of 4E-09.

Annual deer, geese, and wild turkey hunts are held on the ORR. Bone and tissue samples are analyzed from each group of animals, and the geese and turkey are subjected to whole-body gamma scans. Hunters take their deer to various stations on the ORR where bone and tissue samples are analyzed in the field to ensure that release criteria are met. If 20 picocuries per gram (pCi/g) of beta activity is found in the bone or 5 pCi/g of cesium-137 in edible tissue, the deer is confiscated. In 1997, 429 of the 438 deer killed were released to hunters. An individual who consumed one average-weight deer (about 37 kg or 82 lbs) with the average concentration of 0.07 pCi/g of cesium-137 would have received an effective dose equivalent of about 0.07 mrem; a calculated fatal cancer risk would be 4E-08. Tissue samples were not analyzed for strontium-90 in 1997, but the maximum concentration in 1996 was 0.002 pCi/g. The maximum hypothetical effective dose equivalent, about 3 mrem, was assumed to result from eating the heaviest deer with the highest concentration of cesium-137 (1.37 pCi/g) and of strontium-90 (0.002 pCi/g) (ORNL 1998). This would result in a hypothetical cancer risk of 2E-06.

During 1997, 83 geese were collected and only 1 was retained. Approximately one-half of the weight of the goose is edible, and the average cesium-137 concentration in 1997 was 0.07 pCi/g. Analysis for strontium-90 was not performed in 1997, but in 1995, the average concentration in tissue was approximately 7 pCi/g. Most hunters kill an average of one or two geese per hunting season. If a person consumed an average-weight goose (about 4 kg or 9 lbs) with 0.07 pCi/g of cesium-137 and 7 pCi/g of strontium-90, the individual would receive an effective dose equivalent of about 2 mrem. The calculated fatal cancer risk would be 1E-06. The highest possible effective dose equivalent in 1997 would have been about 4.5 mrem, which corresponds to a hypothetical cancer risk of 2E-06, and would have resulted from eating a hypothetical goose (the heaviest goose with the maximum cesium-137 and strontium-90 concentrations) (ORNL 1998).

A total of 90 wild turkeys were killed on the ORR during 1997, and one of these was retained. The average weight of the turkeys was 8.5 kg (19 lbs), and the average cesium-137 concentration was 0.1 pCi/g. The strontium-90 concentration was determined from tissue samples analyzed in 1997 to be

0.22 pCi/g. A person who ate an average turkey would have received an effective dose equivalent of about 0.021 mrem. A person who ate a hypothetical turkey (a combination of the heaviest turkey and the highest cesium-137 concentration) would have received an effective dose equivalent of about 0.17 mrem (ORNL 1998).

Dose estimates were also performed from eating fish from the Clinch and Tennessee River systems. Fish are collected from three locations on the Clinch River, and the edible portion is analyzed for selected metals, pesticides, PCBs, cobalt-60, cesium-137, and total strontium. A maximally exposed individual was assumed to have eaten 21 kg (46 lbs) of fish in 1997 for this analysis, with the average person consuming 6.9 kg (15 lbs). Based on the fish samples, a maximally exposed individual would have received an effective dose equivalent of 0.045 mrem, and the collective population effective dose equivalent was 0.017 person-rem (ORNL 1998).

3.10.3.3 Waterborne radionuclides

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system via the Clinch River and various feeder streams. Discharges from ORNL enter the Clinch River via White Oak Creek and White Oak Lake. Two methods are used to estimate radiation doses to persons who drink the water, swim, boat, and use the shoreline at various locations along the Clinch and Tennessee Rivers. The first method analyzes water samples for radionuclide concentrations. This allows for the direct measurement of contaminants in the samples, but also includes naturally occurring radionuclides. The presence of some radionuclides may be overstated, since all radionuclides are reported even if the concentration is below the detection limit (ORNL 1998). The second method uses radionuclide concentrations in water that were calculated from measured radionuclide discharges and known or estimated stream flows. The advantage of this method is that most, if not all, radionuclides discharged from ORR are quantified, and naturally occurring radionuclides are not considered. The disadvantage is that computer models estimate the concentrations of radionuclides in fish and water.

A maximally exposed individual drinking water directly from Melton Hill Lake would have received an effective dose equivalent of about 0.096 mrem according to the analyzed water samples. The collective population dose for the estimated 37,510 persons who would drink this water would be about 1.8 person-rem. This would result in a calculated fatal cancer risk of 9E-04. The dose estimates obtained from the water samples are high, since it was assumed that the individuals drank the water directly from Melton Hill Lake. If the dose estimates are calculated using the amount of radionuclides discharged from ORR to Melton Hill Lake, the doses would be about 300 times lower (ORNL 1998).

There are several water treatment plants along the Clinch and Tennessee River systems that could be affected by discharges from the ORR. The ETTP water plant draws water from the upper Clinch River. Based on water samples taken from the Clinch River, a worker who drank 370 liters (391 quarts) of this water in 1997 would have received an effective dose equivalent of about 0.15 mrem (calculated cancer risk of 8E-08), and the collective population effective dose equivalent to the approximately 2,000 workers at ETTP would have been about 0.29 person-rem (fatal cancer risk of 1E-04). Using radionuclide discharge data, the maximally exposed individual was estimated to receive 0.025 mrem (fatal cancer risk of 1E-08), and the collective effective dose equivalent was 0.05 person-rem (fatal cancer risk of 3E-05) (ORNL 1998). The Kingston municipal water plant is located near the upper Watts Bar Lake and draws water from the Tennessee River. Dose assessments were performed assuming a maximally exposed individual drank 730 liters (771 quarts) of water during 1997 and an average person drank 370 liters (391 quarts). Based on water samples, a maximally exposed individual would receive about 0.40 mrem (calculated cancer risk of 2E-07), and the collective population effective dose equivalent to the approximately 7,438 users from the Kingston plant would be about 1.5 person-rem (ORNL 1998), which would result in a calculated cancer risk of 9E-06.

Other potential exposure pathways analyzed by the ORR for radionuclides in water include swimming or wading, boating, and use of the shoreline. A maximally exposed individual was assumed to swim or wade 27 hours/year, boat for 63 hours/year, and use the shoreline for 67 hours/year. Based on water samples collected around the ORR, a maximally exposed individual would have received a maximum effective dose equivalent of 0.015 mrem (calculated cancer risk of 8E-09) at Melton Hill Lake, and the maximum collective population dose was 0.032 person-rem, which would result in a calculated cancer risk of 2E-05.

After summing the worst-case effective dose equivalents for all water pathways in the Region of Influence, the maximum estimated effective dose equivalent would have been about 1.4 mrem in 1997, with a calculated cancer risk of 7E-07. The maximum estimated collective population effective dose equivalent would have been about 5.7 person-rem (ORNL 1998).

3.10.3.4 Direct radiation

External exposure rates from background sources in Tennessee average about 6.4 microroentgens per hour (μR/hour) and range from 2.9 to 11 μR/hour. These exposure rates are equivalent to an average annual effective dose equivalent of 56 mrem/year and range from 25 to 96 mrem/year. The total average background exposure received by an individual each year is about 300 mrem. Contributing to this background dose is direct exposure from terrestrial radiation, inhalation and ingestion of naturally occurring radionuclides, and exposure to cosmic radiation. The average exposure rate at the perimeter of the ORR during 1997 was about 5.4 μR/hour or 36 mrem/year. All of the measured exposure rates at, or near, the ORR are near background levels except for two locations. Exposure rate measurements taken along a 1.7-km (1.1-mile) length of Clinch River bank averaged 8.4 μR/hour and were about 3 μR/hour above the average exposure rate at the perimeter of ORR. The potentially maximally exposed individual is a hypothetical fisherman who was assumed to have spent 5 hours/week (250 hours/year) near the point of average exposure, which would have resulted in an effective dose equivalent of about 0.25 mrem. The calculated cancer risk from this exposure would be 1E-07. The second elevated exposure measurement is at Poplar Creek, which runs through ETTP. Exposure rate measurements taken at nine locations along Poplar Creek in 1997 ranged from 3.5 to 9.5 μR/hour. The average reading was 6.1 μR/hour or 0.0046 mrem/h. Using the hypothetical fisherman who spent 250 hours/year along the bank, the effective dose equivalent would be about 1 mrem. The calculated risk for this exposure would be 5E-07.

3.10.3.5 Five-year trends

The dose equivalents associated with various exposure pathways for the years 1993–97 are provided in Table 3-16. The dose estimates for direct radiation along the Clinch River and Poplar Creek have been corrected for background. The estimates for direct radiation along the Clinch River in 1994, 1995, and 1996 are overestimated because the source of the radiation was remediated in 1993 and 1994 (ORNL 1998).

Table 3-16. Five-year trends in the total effective dose equivalent for selected pathways

	Effective dose equivalent (mrem)				
Pathway	**1993**	**1994**	**1995**	**1996**	**1997**
All inhalation	1.4	1.7	0.5	0.45	0.41
Fish ingestion	0.2	1.6	0.9	1.2	0.96
Water ingestion (Kingston)	0.07	0.04	0.15	0.32	0.40
Direct radiation (Clinch River)	1	1	1	1	0.25
Direct radiation (Poplar Creek)	1	1	1	1	1

3.10.4 Chemicals

Non-radioactive emissions are regulated by the TDEC Division of Air Pollution Control. The small quantities of chemicals released by the ORR to the atmosphere are allowed under the air pollution control rules and do not pose a threat to human health.

3.10.4.1 Airborne chemicals

Operations at ORNL result in the release of small quantities of chemicals to the atmosphere and do not require stack sampling or monitoring. A steam plant and two small, oil-fired boilers are the largest emission sources and account for 98% of all allowable emissions at ORNL. Airborne contaminants released by ORNL are shown in Table 3-17 (ORNL 1998).

Table 3-17. Actual versus allowable[a] air emissions from ORNL steam production during 1997

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate	2	441	0.5
Sulfur dioxide	1072	9062	11.8
Nitrogen oxides	103	531	19.4
Volatile organic compounds	1	3	33.3
Carbon monoxide	82	336	24.4

[a]Per the Clean Air Act Title V permit.
ORNL = Oak Ridge National Laboratory.

There have been a total of 14 6-minute release periods of excess emissions and 7 occasions where air monitors were out of service at the Y-12 Plant in 1997. The majority of nonradiological contaminants were from the Y-12 Steam Plant. Nonradiological emissions include sulfur oxides, nitrogen oxides, particulates, hydrochloric acid, and carbon monoxide. The ETTP operated 12 major emission sources under the Tennessee Title V Major Source Operating Permit Program Rules. The major sources of emissions were the three remaining steam-generated units in operation at the K-1501 Steam Plant and the Toxic Substances Control Act Incinerator. The major contaminants emitted included sulfur dioxide, nitrogen oxides, volatile organic compounds, and carbon monoxide (ORNL 1998).

3.10.4.2 Waterborne chemicals

Current risk assessment methodology uses the term "hazard quotient" to evaluate noncarcinogenic health effects. A hazard quotient value less than one indicates that the potential for adverse health effects is unlikely. The hazard quotient is a ratio that compares the estimated exposure dose or intake to a reference dose. The reference dose is an estimate of a daily exposure level in humans that is unlikely to result in harmful effects during a lifetime. Most of the reference doses are obtained from research involving animals. Therefore, a safety factor of 10 to 1,000 is added for use in humans (i.e., the safe doses in humans are set at 10 to 1,000 times lower than the dose that results in no effect or a non-life-threatening effect in animals) (ORNL 1998).

Fish samples were taken upstream and downstream of the ORR and analyzed for a number of metals, pesticides, and PCBs. The hazard quotients for 1997 from the fish samples are summarized in Table 3-18. In many cases, the hazard quotients, especially for pesticides and PCBs, were calculated using concentrations estimated at or below the analytical detection limit. Because of the analytical

Table 3-18. Chemical Hazard Quotients for metals in fish (ORNL 1997)

Parameters	Sunfish			Catfish		
	CRK70[a]	CRK32[b]	CRK16[c]	CRK70[a]	CRK32[b]	CRK16[c]
Hazard Quotients for Metals						
Antimony	[d]			<3E+00	<3E+00	<3E+00
Arsenic				<4E+00	<4E+00	<4E+00
Beryllium				<4E-03	<4E-03	<4E-03
Cadmium				<1E-01	<2E-01	<1E-01
Chromium	~4E-02[e]		~7E-02	<5E-02	<5E-02	<5E-02
Copper	7E-03	8E-03	5E-03			
Lead				<3E+0	<3E+0	<3E+00
Mercury	~6E-01	6E-01	2E+00			
Nickel			~8E-03	<1E-02	<1E-02	<1E-02
Selenium		<2E-01		<2E-01	<3E-01	<2E-01
Silver				<3E0-2	<3E-02	<3E-02
Zinc	4E-02	4E-02	5E-02			
Hazard Quotients for Pesticides and Aroclors						
Chlordane			1E-01			
Benzine Hexachloride			~1E+00			
Gamma BHC			~6E-01			
4,4′DDT			~2E-02			
Endosulfan I			~7E-04			
Endosulfan II			~1E-03			
Endosulfan sulfate			~3E-03			
Endrin			~3E-02			
Endrin aldehyde			~4E-01			
Heptachlor			~8E-03			
Heptachlor epoxide			~3E-01			
Methoxychlor			~8E-03			
Aroclor-1016			~7E-01			
Aroclor-1221			~4E+03			
Aroclor-1232			~4E+03			
Aroclor-1242			~4E+03			
Aroclor-1248			~4E+03			
Aroclor-1254			~3E+00			
Aroclor-1260	~2E+03	~1E+03	~2E+03			

[a]Melton Hill Reservoir, above Oak Ridge City input.
[b]Clinch River, downstream of ORNL.
[c]Clinch River, downstream of all DOE inputs.
[d]A blank space indicates the parameter was undetected.
[e]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.
Source: Adapted from ORNL 1998.

detection limitations, the actual fish tissue concentrations are unknown. Drinking water was analyzed upstream and downstream of the ORR discharge points for various metals and chemicals. Elevated aluminum and iron hazard quotients were found both upstream and downstream of the ORR. The hazard quotients for drinking water are shown in Table 3-19.

For carcinogens, the estimated dose or intake from ingestion of water or fish is divided by the chronic daily intake, which corresponds to a 1E-05 lifetime risk of developing cancer. In sunfish collected downstream of the ORR and analyzed for carcinogens, there was a cancer risk of 1E-05 due to aldrin, dieldrin, and toxaphene. Because of analytical detection limitations, the actual fish tissue concentrations are not known (ORNL 1998).

Table 3-19. Chemical Hazard Quotients for drinking water (ORNL 1997)

Chemical	Hazard Quotient		
	CRK 70[a]	**CRK 23[b]**	**CRK 16[c]**
Metals			
Aluminum	~1.3[d]	~1.4	~2.1
Antimony	[e]	~3.2	
Barium	~3E-02	~3E-02	4E-02
Boron	6E-03	7E-03	7E-03
Chromium	~5E-02	~5E-02	~5E-02
Copper	~4E-03	~7E-03	
Iron	~1E-02	~1	1.6
Lead	~3E+01	~3	
Manganese	~4E-02	3E-02	4E-02
Strontium	4E-03	4E-03	4E-03
Thallium	~2E+01		
Uranium	~4E-03	~4E-03	~4E-03
Vanadium	~1.3	~1.3	
Zinc	~3E-03	~2E-03	~2E-03
Volatile Organics			
Acetone	~2E-03	~2E-03	~2E-03
2-Butanone	~4E-04	~4E-04	~4E-04
Toluene	~6E-04		
Xylene	~6E-05		

[a]Melton Hill Reservoir, above Oak Ridge City input.
[b]Clinch River, downstream of ORNL.
[c]Clinch River, downstream of all DOE inputs.
[d]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.
[e]A blank space indicates the parameter was undetected.
Source: Adapted from ORNL 1998.

3.11 ACCIDENTS

The potential for accidents from human error, equipment failure, or natural phenomena would result in the release of radiation, radioactive materials, or hazardous materials. Based on data obtained from the ORNL Safety Information Database Module on the Injury/Illness Historical Performance Report for January 1, 1999, through December 31, 1999, the total recorded injuries at ORNL for 1999 were 170, which is a rate of 4.56 per 100 full-time employees working for one year (ORNL 1999b).

3.12 NOISE

The area around the Melton Valley Storage Tanks is industrial, with the site serving as a waste storage area. The activities in this area are sporadic and associated with traffic and occasional equipment use. A baseline noise survey was conducted for the project site area in July 1999 by Bechtel Jacobs; details of the survey are included in Appendix C.4. The Old Melton Valley Road that connects with Tennessee State Route 95 [roughly 1.6 km (1 mile) west of the proposed site] was being upgraded during the survey, so heavy construction equipment was in use. Eleven noise monitoring stations were established (Figure 3-20). The monitoring stations ranged in location from west of the proposed site and immediately adjacent to Tennessee State Route 95, to east of the proposed site adjacent to the Melton Valley Storage Tanks. The entire surveyed area is relatively quiet. Daily equivalent noise level (Leq) values were generally in the 50 to 70 dBA range. By comparison, normal human speech is approximately 60 to 65 dBA. The Leq is a metric that measures all noise within the frequency range of the instrument over a given time interval (in this case one hour), computes an average noise level, and assumes this noise level was continuous over the total interval measured. Results of the monitoring effort are presented in Appendix C.4.

The noise levels adjacent to State Route 95 (monitoring location 1) were relatively constant over a 24-hour period with daily Leqs of 61.1 and 64.7 for the 2 days data were collected (Table 3-20). Monitoring location 2, adjacent to the Old Melton Valley Road, showed substantially greater noise levels (20 dBA Leqs greater) during hours when heavy equipment associated with the road upgrade was present. For one day, monitoring location 7 also shows noise levels greatest during periods when construction workers were present. The other locations either had a relatively constant noise environment or they showed diurnal peaks when workers were not generally present. It is probable that wildlife such as frogs and crickets contributed to the late-night noise peaks at several locations (Table 3-20).

3.13 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The Region of Influence for the proposed action includes Anderson, Knox, Loudon, and Roane Counties (Figure 3-21). Approximately 90% of ORR employees reside in this region (DOE 1998c). The region includes the cities of Clinton, Oak Ridge, Knoxville, Loudon, Lenoir City, Harriman, and Kingston. This section provides a description of the characteristics, housing, infrastructure, and the local economy.

3.13.1 Demographic Characteristics

Approximately 7,500 people live within 8 km (5 miles) of the center of the proposed project site. Excluding the residential area of Oak Ridge with a population of 27,310, the population density within 10 km (6 miles) of the proposed TRU Waste Treatment Facility generally averages less than 38 people/square kilometer (100 people/square mile). Oliver Springs lies 11 km (7 miles) northwest of the ORR and has a population of 3,400. Clinton, Tennessee, located 16 km (10 miles) to the northeast of the ORR, has a population of 9,000. Approximately 6,100 people live in Lenoir City, 11 km (7 miles) southeast of the ORR. Kingston is located 11 km (7 miles) to the southwest of the ORR and has 4,600 residents. Approximately 7,100 people reside in Harriman, Tennessee, which is 13 km (8 miles) west of the ORR. Knoxville is the largest metropolitan area within 80 km (50 miles) of the facility and has a population of 165,000 people. In all, approximately 880,000 people reside within 80 km (50 miles) of the facility (ORNL 1995).

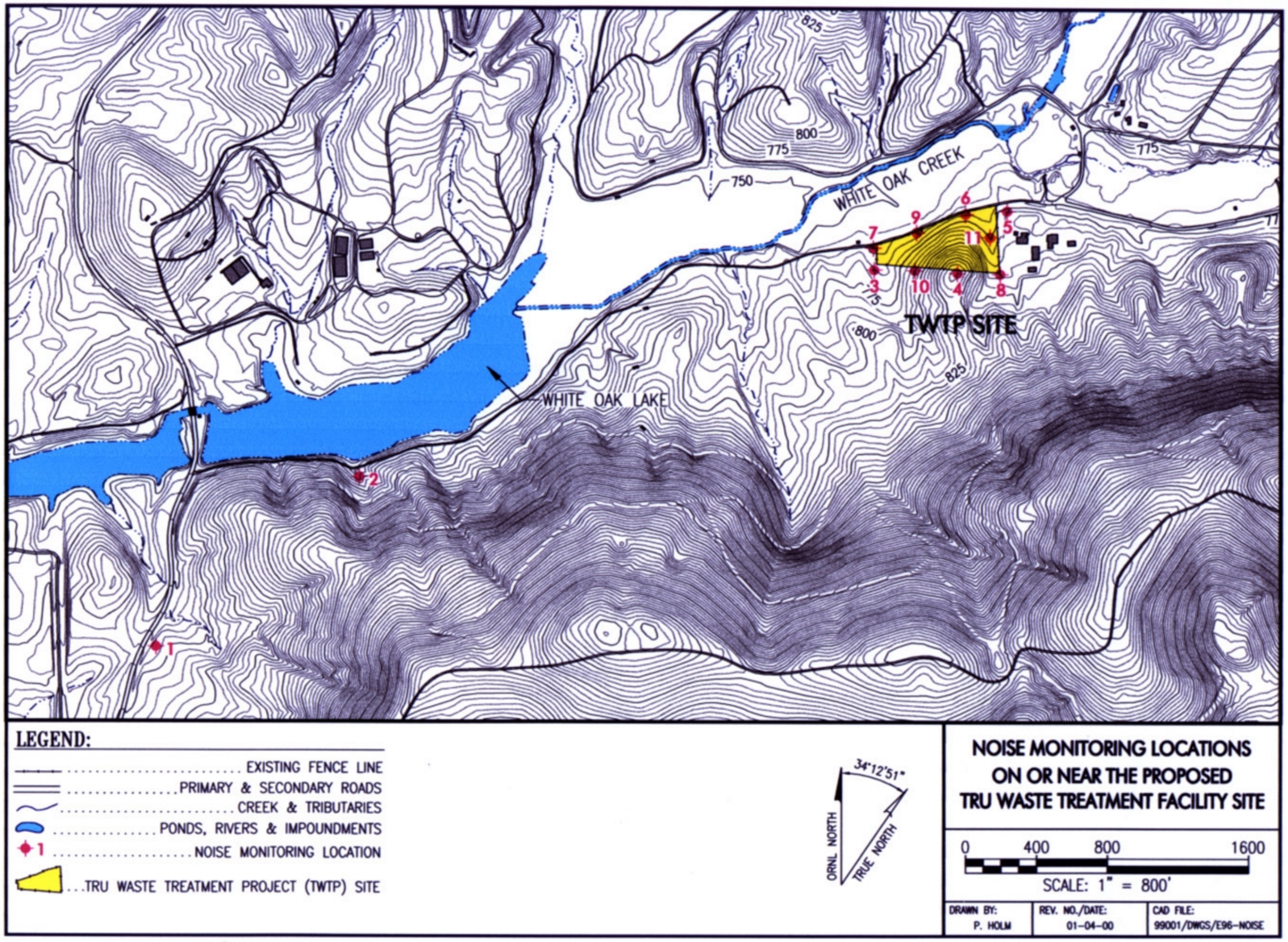


Figure 3-20. Eleven noise monitoring stations were located on, or near the proposed TRU Waste Treatment Facility site boundary.

Table 3-20. Noise monitoring data for Melton Valley proposed TRU waste facility
[noise levels (Leq per hour) in Melton Valley, Oak Ridge, Tennessee]

Location number and sample event	1a	1b	2a	2b	2e	3a	3b	3d	4a	4b	4c	5a	5b	6e	7c	7e	8d	9d	9e	10d	10e	11d
Hour (military)																						
0	60.5	61.9	53.1	53.5	55.4	56.1	61.2	58.2	58.4	58.7	59.3	59.6	59.0	57.4	55.9	63.6	63.1	60.5	59.9	57.2	58.8	62.6
1	59.0	60.3	51.7	51.3	54.5	53.3	54.5	57.4	55.8	55.5	57.7	58.6	58.2	56.0	53.8	58.6	60.5	59.4	58.9	56.3	57.6	61.5
2	56.7	56.6	49.4	48.7	53.3	50.1	50.4	55.1	52.3	51.1	55.3	57.8	56.9	54.5	51.9	57.9	59.3	58.0	57.9	54.1	55.3	60.4
3	52.7	55.9	46.6	46.6	51.3	49.3	49.9	53.1	50.6	49.5	51.3	57.3	56.4	52.9	49.8	56.2	58.5	54.0	55.2	51.0	51.6	57.1
4	52.9	57.5	42.9	42.4	47.6	47.6	48.2	47.3	49.1	48.2	48.9	57.1	56.2	54.2	48.0	56.4	57.6	48.8	53.5	46.9	52.9	55.0
5	60.9	64.6	43.4	43.2	46.6	46.6	48.5	45.1	48.2	47.9	47.8	57.1	55.9	47.5	47.0	53.2	57.1	48.5	49.1	42.5	43.5	54.6
6	60.6	68.4	45.6	45.3	47.0	50.6	50.5	58.8	49.3	48.1	50.3	56.6	56.3	48.3	51.8	57.6	60.8	57.3	49.3	61.7	43.5	61.4
7	59.4	67.8	45.8	66.2	71.0	50.4	52.5	52.1	49.6	51.1	49.6	56.8	57.1	49.0	56.7	50.0	58.4	54.5	51.2	52.8	43.4	57.9
8	58.9	66.3	44.8	73.1	72.5	50.3	52.5	55.1	49.9	53.0	51.8	57.3	57.0	51.8	72.6	55.2	59.3	56.0	59.2	56.5	46.9	60.7
9	55.6	64.9	43.9	78.2	74.7	50.0	52.4	51.3	50.1	51.4	53.5	58.0	56.8	50.9	77.4	52.7	57.7	51.0	57.0	49.8	52.1	57.3
10	54.0	63.1	43.8	69.6	71.7	49.8	50.2	47.1	49.0	52.3	58.2	57.7	57.2	54.2	80.7	55.6	57.0	52.4	59.0	47.5	54.5	55.3
11	55.9	64.7	45.8	48.5	65.0	49.5	51.3	46.1	49.2	51.3	54.0	57.8	56.7	51.9	71.2	50.7	56.3	48.4	56.5	45.3	51.8	56.5
12	55.8	63.5	44.9	46.4	59.4	51.6	50.1	50.3	51.2	49.9	58.7	58.0	56.8	49.3	51.9	51.1	57.2	55.8	55.3	51.8	50.5	56.8
13	55.6	64.0	63.5	47.4	70.3	50.4	49.8	50.8	49.7	49.9	53.6	57.8	57.2	48.6	51.9	51.2	56.1	56.2	55.1	51.0	51.1	58.4
14	56.4	64.0	54.7	55.8	61.7	50.8	49.7	48.9	50.5	49.0	53.0	57.2	56.5	50.7	50.8	52.5	55.4	54.2	54.5	48.2	51.6	55.4
15	59.7	67.7	46.3	54.5	77.2	49.9	48.9	49.6	49.4	48.8	52.3	56.9	56.4	49.4	57.1	46.3	54.7	64.2	50.3	49.7	47.4	57.7
16	59.7	67.0	46.4	49.7		49.4	47.6	59.0	49.6	48.5	52.4	57.1	56.2	51.1	52.3		56.1	53.2		54.3	46.4	54.9
17	63.1	67.1	45.6	49.3	49.4	48.1	46.0	58.6	48.5	48.3	49.4	57.0	56.3	53.4	47.3	46.4	55.0	53.3	47.8	53.7	44.7	53.3
18	61.7	64.3	44.1	46.2	49.8	47.8	47.1	42.4	48.9	48.3	47.7	57.4	56.4	49.0	44.8	45.6	55.7	45.8	44.1	41.1	42.9	53.0
19	60.8	64.2	43.3	43.7	50.3	47.7	46.3	43.2	48.7	48.3	47.9	57.6	56.9	51.2	44.7	44.5	56.1	43.9	46.1	42.0	42.6	52.8
20	58.1	61.5	45.3	43.8	56.5	48.0	49.0	47.5	48.8	49.5	48.9	57.8	57.3	52.2	46.1	47.4	57.1	48.7	49.4	46.1	48.8	54.6
21	63.0	65.2	50.6	52.7	57.2	55.4	58.1	58.8	55.8	57.7	59.2	60.2	59.5	60.1	57.9	61.8	62.8	60.7	61.0	57.7	58.5	64.6
22	62.3	64.7	54.9	56.2	57.0	59.1	60.4	60.4	60.1	60.5	61.1	61.1	59.9	59.7	63.5	65.7	62.6	62.1	62.5	58.9	60.2	65.4
23	57.9	63.4	53.8	55.0	57.0	58.1	59.8	59.9	59.8	59.4	60.4	60.4	59.4	58.6	59.0	66.7	61.8	61.3	62.2	57.9	59.6	63.8
daily Leq	61.1	64.7	61.0	66.4	67.3	52.7	53.6	55.4	53.6	53.7	55.5	58.2	57.4	54.3	69.4	58.7	58.9	57.0	57.1	54.5	54.1	59.7
Lmax	87.6	90.0	87.8	104.4	96.8	70.0	64.8	78.8	72.1	73.2	75.9	74.4	68.0	81.5	90.5	82.7	81.6	93.0	88.8	90.1	81.7	82.5

For locations, see Figure 3-20 and text descriptions.

Sample Events:
a - 7/13-14/99
b - 7/14-15/99
c - 7/15-16/99
d - 7/19-20/99
e - 7/20-21/99

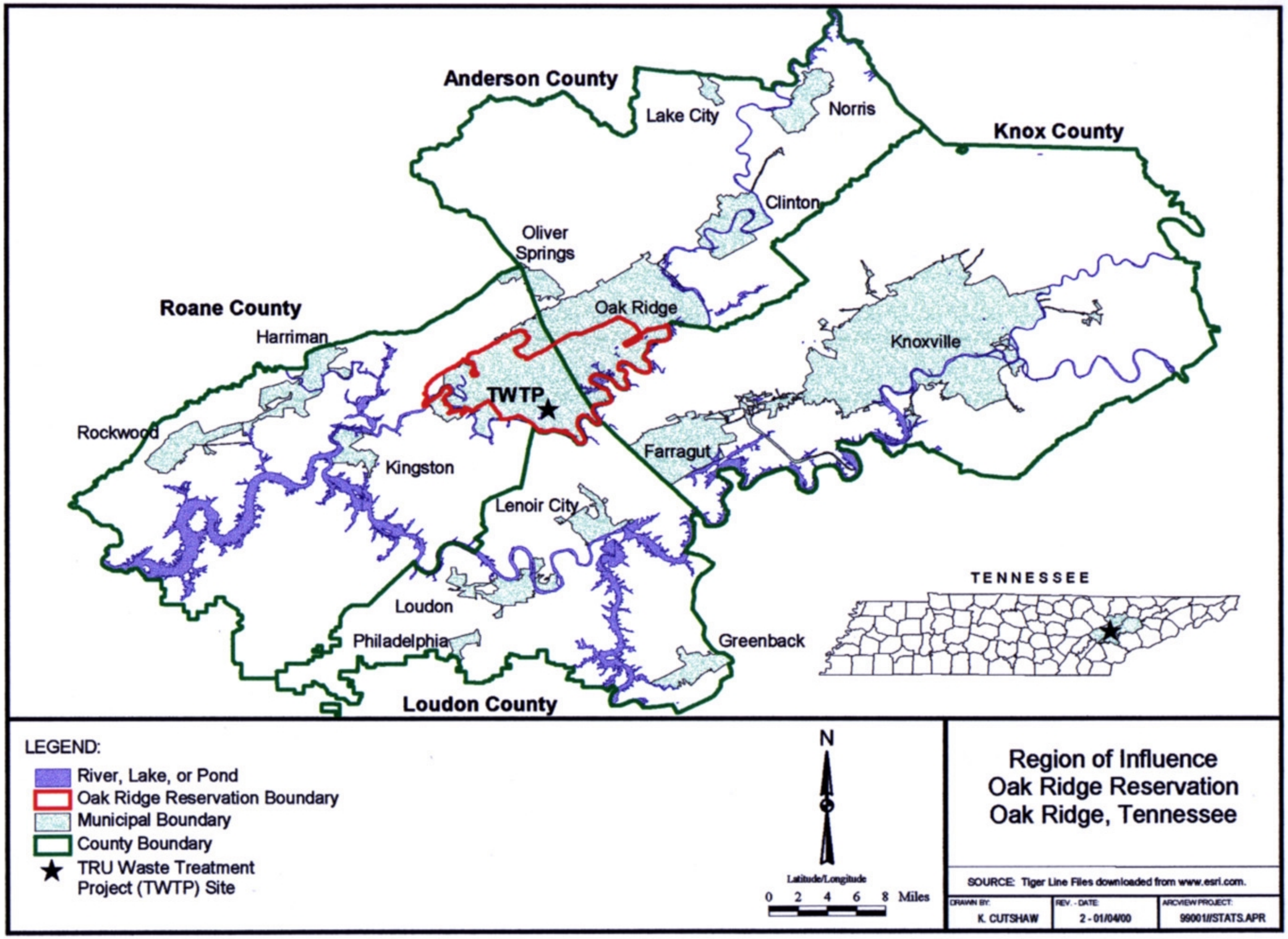


Figure 3-21. Region of Influence for the Oak Ridge Reservation.

Population trends and projections for each of the counties in the four-county Region of Influence are presented in Table 3-21. Of the four counties, Knox has the largest population, with 70% of the 1996 regional population of 523,252. Anderson County accounted for 14% of the regional population, Roane County for 9%, and Loudon County accounted for the remaining 7%. The region represents approximately 10% of the state's population. The TDEC has indicated that the population in the region will likely decline to 512,399 by year 2000 and then increase slightly by year 2005. Roane County is the exception to this trend, as it is projected to grow 24%.

Table 3-21. Regional population trends and projections in the Oak Ridge Region of Influence

County	1980	1990	1996	2000	2005
Anderson	67,346	68,250	71,587	68,181	66,347
Knox	319,694	335,749	364,566	353,721	360,033
Loudon	28,553	31,255	37,240	34,149	36,458
Roane	48,425	47,277	49,859	56,348	61,984
Region Total	464,018	482,531	523,252	512,399	524,822
State	4,591,023	4,877,185	5,235,358	5,178,587	5,305,137

Sources: U.S. Bureau of Census 1990a; TEDC 1994–97.

Population data for the cities in the region are presented in Table 3-22. Between 1990 and 1996, the populations of the four-county region and the state both grew less than 1% per year.

Table 3-22. Population for incorporated areas within the ORR region

Communities	1990	1996	Percent growth
Clinton	8,972	9,320	3.9
Oak Ridge	27,310	27,742	1.6
Knoxville	169,761	167,535	-1.3
Loudon	4,288	4,544	6.0
Lenoir	6,147	8,890	44.6
Harriman	7,119	7,006	-1.6
Kingston	4,552	4,935	8.4

ORR - Oak Ridge Reservation.
Source: U.S. Bureau of Census 1990a; DOE 1999a.

Population by race and ethnicity for the region is presented in Table 3-23. The 1990 census data reflect racial and ethnic compositions in the four counties. There is little variation among the four counties, and Caucasians make up more than 90% of the combined population. African-Americans compose 7% of the population.

Table 3-23. 1990 Population by race and ethnicity for the ORR region

All persons, race/ ethnicity	Anderson		Knox		Loudon		Roane		Total	
	Number	%[a]	Number	%[a]	Number	%[a]	Number	%[a]	Number	%[a]
All Persons	68,250	100	335,749	100	31,255	100	47,277	100	482,531	100
Caucasian	64,745	95	301,788	90	30,762	98	45,422	96	442,717	92
African-American	2,681	4	29,299	9	362	1	1,534	3	33,876	7
American Indian[b]	195	<1	996	<1	46	<1	87	<1	1,324	<1
Asian/ Pacific Islander	540	<1	3,136	<1	55	<1	177	<1	3,908	1
Hispanic of any race[c]	582	1	1,935	1	107	<1	273	1	2,897	1
Other races	89	<1	530	<1	30	<1	57	<1	706	<1

[a]Percentages may not total to 100 due to rounding.
[b]Numbers for Aleuts and Eskimos were placed in the "other" category, given their small number.
[c]In the 1990 Census, Hispanics classified themselves as White, Black, Asian/Pacific Islander, American Indian, Eskimo, or Aleut. To avoid double counting, the number of Hispanics was subtracted from each of the race categories.
ORR - Oak Ridge Reservation.
Source: U.S. Bureau of Census 1990a.

3.13.2 Housing

Regional housing characteristics are presented in Table 3-24. In 1990, vacancy rates in the region ranged between a low of 6% in Loudon County to a high of 9% in Roane County. Among all occupied housing units in the region, approximately two-thirds were owner occupied.

Housing vacancy rates for selected regional cities and towns are similar to county rates. In 1990, the county vacancy rate for all units was 7%, while the combined vacancy rate for the seven selected communities (refer to Table 3-24) was 8%. Median home value was similar in Roane, Loudon, and Anderson Counties, ranging between $48,700 to $55,100. Knox County median home values were higher at $63,900. Rents ranged from $280 to $351 across the Region of Influence.

Table 3-24. Housing summary for the ORR region, 1990, by county

	Anderson County		Knox County		Loudon County		Roane County	
	Number	%[a]	Number	%[a]	Number	%[a]	Number	%[a]
Total housing units	29,323	100	143,582	100	12,995	100	20,334	100
Occupied	27,384	93	133,639	93	12,155	93	18,453	91
Vacant	1,939	7	9,943	7	840	6	1,881	9
Median home Value	$55,100	NA	$63,900	NA	$51,000	NA	$48,700	NA
Gross rent	$342	NA	$351	NA	$280	NA	$287	NA

ORR = Oak Ridge Reservation
NA = Not applicable.
[a]May not total 100 due to rounding.
Sources: U.S. Bureau of Census 1990a; U.S. Bureau of Census 1996.

3.13.3 Infrastructure

The infrastructure section characterizes the region's community services with indicators such as education, health care, and public safety.

3.13.3.1 Education

There are eight school districts within the four-county Region of Influence. Information regarding these districts is presented in Table 3-25. The school districts in the region receive funding from local, state, and federal sources, but the percentage received from each source varies. Local funding varies from a low of 31% in Loudon County to a high of 52% in Knox County. State funding varies between 43% in Knox County and 63% in Loudon County, and federal funding ranges between a low of 5% in Knox County and a high of 12% in Anderson County.

Table 3-25. Public school statistics in the ORR region, 1996–97 school year

County	Number of schools	Student enrollment[a]	Teachers[a]	Teacher/student ratio	Per-student operational expenditures
Anderson	27	13,867	840	1:16	$5,206
Knox	84	57,693	3153	1:18	$4,191
Loudon	13	6,900	335	1:21	$3,870
Roane	19	8,356	455	1:18	$4,343

ORR= Oak Ridge Reservation.
[a]Full-time equivalent figures.
Source: Tennessee Department of Education 1997.

3.13.3.2 Health care

There are eight hospitals currently serving the region. Table 3-26 presents data on hospital capacity and usage. Average statistics for the hospitals indicate that there are approximately 2,400 acute-care hospital beds in the region, about 46% of which are available on any given day. This capacity is considered adequate to serve the health needs of the local population.

Table 3-26. Hospital capacity and usage in the ORR region

Hospital	Number of hospitals	Number of beds[a]	Annual bed-days used[b] (%)
Anderson	1	281	63
Knox	5	1923	53
Loudon	1	62	23
Roane	1	94	50

ORR = Oak Ridge Reservation.
[a]The number of acute-care beds.
[b]Based on the number of people discharged and the average length of stay divided by total beds available annually.
Source: The American Hospital Directory, Inc. 1999.

3.13.3.3 Police and fire protection

The Knoxville Police Department has 400 officers with an approved Fiscal Year 1998 budget of $26.4 million. In addition, the Oak Ridge Police Department has 45 officers with an approved Fiscal Year 1996 budget of $2.3 million. The Knoxville County Fire Department has 13 fire stations, staffed by 118 Fire Department personnel. The Oak Ridge Fire Department provides fire suppression, medical/rescue, and fire prevention services to both ORNL and the Oak Ridge community (DOE 1999a).

3.13.4 Local Economy

This subsection provides information on the economy of the region, including employment, income, and fiscal characteristics.

3.13.4.1 Employment

Regional employment data for 1991–96 are summarized in Table 3-27. The 1998 average unemployment rate for the Region of Influence was 3.4%, ranging from 3.1% in Knox County to 5.0% in Roane County (Tennessee Department of Employment Security 1999).

Table 3-27. Region of Influence employment data, 1991–96

County	Number employed		Percent change
	1991	1996	
Anderson	37,395	41,001	9.64
Knox	185,704	210,506	13.36
Loudon	9,538	11,142	16.82
Roane	21,305	23,646	10.99
Region	253,942	28,6295	12.74

Source: Bureau of Economic Analysis 1999.

DOE-related facilities and contractor employment declined from 18,165 workers in 1995 to 14,534 in 1997, of which 13,154 lived in the four-county impact region (DOE 1996b, 1998b;

Bridgeman 1997; Neal 1998). Table 3-28 shows the distribution of ORR-related employment across the relevant counties in 1996. The distribution in 1997 was similar, although the later figures included Oak Ridge residents in both Anderson and Roane County totals. Knox County held the largest share of the region's ORR-related employment (45%), followed by Anderson County with 32%, and Roane County with 16%. Loudon County accounted for the remaining 6%.

Table 3-28. Distribution of DOE-related employment in Region of Influence, 1996

County	1996	
	Number employed	Percent
Anderson	4,956	32
Knox	6,939	45
Loudon	962	6
Roane	2,493	16
Region of Influence Total	15,350	100

DOE = U.S. Department of Energy.
Source: Bridgeman 1997.

Table 3-29 presents employment by industry for the Region of Influence with government, manufacturing, retail trade, and services being the principal economic sectors. Services employment is the largest employment sector in the region, although manufacturing is nearly as large in Loudon County.

Table 3-29. Employment distribution by industry for the four-county Region of Influence

Industry	Anderson County	Knox County	Loudon County	Roane County	Region of Influence	State of Tennessee
	Number employed by industry (1996)					
Farm	582	1,453	1,214	606	3,855	93,383
Agriculture Services	319	2,202	229	105	2,855	28,435
Mining	123	587	18	32	760	7,125
Construction	4,258	15,829	1068	981	22,136	187,246
Manufacturing	11,114	24,875	3,040	6,539	45,568	534,099
Transportation and Public Utility	1,838	12,244	811	633	15,526	165,715
Wholesale Trade	647	16,088	290	448	17,473	151,914
Retail Trade	(D)	46,614	2,180	(D)	48,794	545,934
Finance, Insurance, and Real Estate	2,177	17,554	894	713	21,338	212,589
Services	(D)	76,010	3,412	(D)	79,422	879,043
Government	5,421	37,474	1,733	4,067	48,695	405,205

(D) = Data withheld to avoid disclosure when there are less than four businesses in an industry classification.
Source: Bureau of Economic Analysis 1996.

3.13.4.2 Income

The total regional income in 1996 was approximately $12.0 billion. DOE-related payroll accounted for about 6% of that income ($725 million). In 1997, DOE-related payroll in the region declined to $680 million (DOE 1998c), reflecting a downward trend in DOE activities that is expected to continue. Per capita income data for the region and the state are presented in Table 3-30. Over the period from 1991 to 1996, the per capita incomes in the four-county Region of Influence grew between 23 and 26%. This growth rate was slightly below the statewide increase in income of 28%.

Table 3-30. Per capita income data for the four-county Region of Influence and the State of Tennessee

Area	Per Capita Income 1991 ($)	Per Capita Income 1996 ($)	Percent Increase
Anderson County	18,040	22,292	24
Knox County	18,970	23,952	26
Loudon County	15,697	19,341	23
Roane County	15,551	19,601	26
State of Tennessee	16,976	21,808	28

ORR = Oak Ridge Reservation.
Source: Bureau of Economic Analysis 1999.

Table 3-31 shows the percentage of persons whose incomes were below the poverty level in 1990 for the four-county Region of Influence. The percentage ranged from 13.4% in Loudon County to 15.8% in Roane County, compared to a state average of 15.7%.

Table 3-31. Percent of individuals with incomes below poverty line in the four-county Region of Influence and the State of Tennessee, 1990

Area	Percent
Anderson County	14.2
Knox County	13.6
Loudon County	13.4
Roane County	15.8
State of Tennessee	15.7

ORR = Oak Ridge Reservation.
Source: Bureau of the Census 1995.

3.13.4.3 Fiscal characteristics

Municipal and county general fund revenues in the Region of Influence are presented in Table 3-32. The general fund supports the ongoing operations of local governments, as well as community services, such as police protection and parks and recreation. The State of Tennessee does not have state or local personal income tax. Under Tennessee constitutional law, property taxes are assessed as follows:

- Residential property equals 25% of the appraised value.
- Commercial/industrial property equals 40% of the appraised value.
- Personal property equals 30% of the appraised value.

The largest revenue sources for the counties' general fund have traditionally been local taxes (which include taxes on property, real estate, hotel/motel receipts, and sales) and intergovernmental transfers from the federal or state government. Over 80% of the 1999 general fund revenue came from these combined sources (DOE 1999a).

Table 3-32. Municipal and county general fund revenues in the ORR region, Fiscal Year 1997

Revenue by source	Anderson County ($1,000)	%	Knox County ($1,000)	%	Loudon County ($1,000)	%	Roane County ($1,000)	%
Local taxes[a]	12,732	40	232,145	56	4,147	68	22,970	45
Licenses and permits	34	<1	1,633	<1	178	3	102	<1
Fines and forfeitures	56	<1	3,086	1	157	3	302	1
Charges for service	2,640	8	21,811	5	43	1	1,167	2
Intergovernmental[b]	14,483	45	145,582	35	638	11	22,826	45
Interest	1,285	4	10,982	3	—[c]	NA	1,183	2
Miscellaneous income	680	2	483	<1	911	14	2,474	5
Total	31,910	100	415,722	100	6,074	100	51,024	100

ORR = Oak Ridge Reservation
[a]Local taxes include real and personal property taxes, hotel/motel taxes, and local sales taxes.
[b]Intergovernmental includes state transfers and federal funds.
[c]Interest revenue not identified separately for Loudon County.
NA = not available.
Source: DOE 1999a.

3.14 ENVIRONMENTAL JUSTICE

Figure 3-22 illustrates the distribution of minority populations in the census tracts that immediately surround the ORR. A minority population consists of any census tract with a minority population proportion greater than the national average of 24.1% (Bureau of the Census 1990a). Minorities include individuals classified as Black not of Hispanic origin, Hispanic, Asian or Pacific Islander, and American Indian or Alaskan Native (CEQ 1997).

In 1990, African-Americans comprised 34.4% of the population in tract 201, and other minorities comprised 6.9% (Bureau of the Census 1990a). For all other Oak Ridge City tracts, minorities comprised 10% or less of the population. For comparison, minorities represented 24.1% of the population nationally and 17% of the population in Tennessee.

There are no federally recognized Native American groups within 80 km (50 miles) of the proposed site. DOE has consulted with Native American groups regarding the status of the ORR as a site of potential importance to Native Americans. While some isolated findings of arrowheads, pottery shards, and charcoal have been found in some project studies over the years, no tribe or group representing Native Americans has ever expressed interest in the ORR as a site of historical importance to Native Americans (Moore 1999). There are no known sensitive areas near the proposed project site. The closest Native American tribe is the Eastern Band of the Cherokee Indians in Cherokee, North Carolina, approximately 110 km (100 miles) southeast of the proposed site.

Figure 3-23 shows the location of low-income populations for the same area. In this analysis, a low-income population includes any census tract in which the percentage of persons with income below the poverty level is greater than the national average of 13.1%. The Tennessee state average is 15.7% (Bureau of the Census 1990b). The highest percentages are in tract 201 (22.9%) and tract 205 (20.4%). The lowest percentages are in tracts 206 (0.3%), 5802 (1.5%), and 301 (1.9%) (Bureau of the Census 1995).

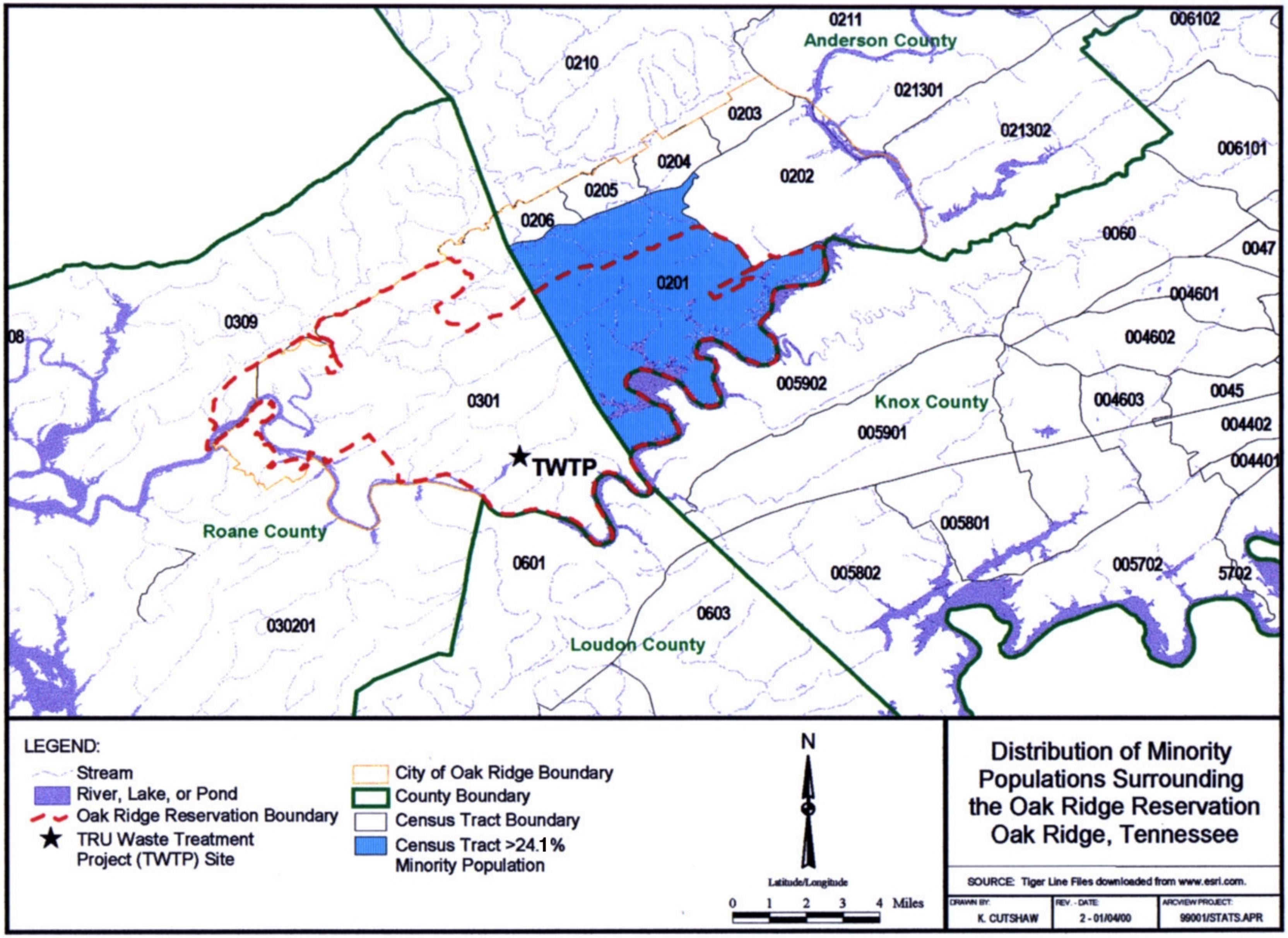


Figure 3-22. Census tracts with a minority population greater than the national average of 24.1%.

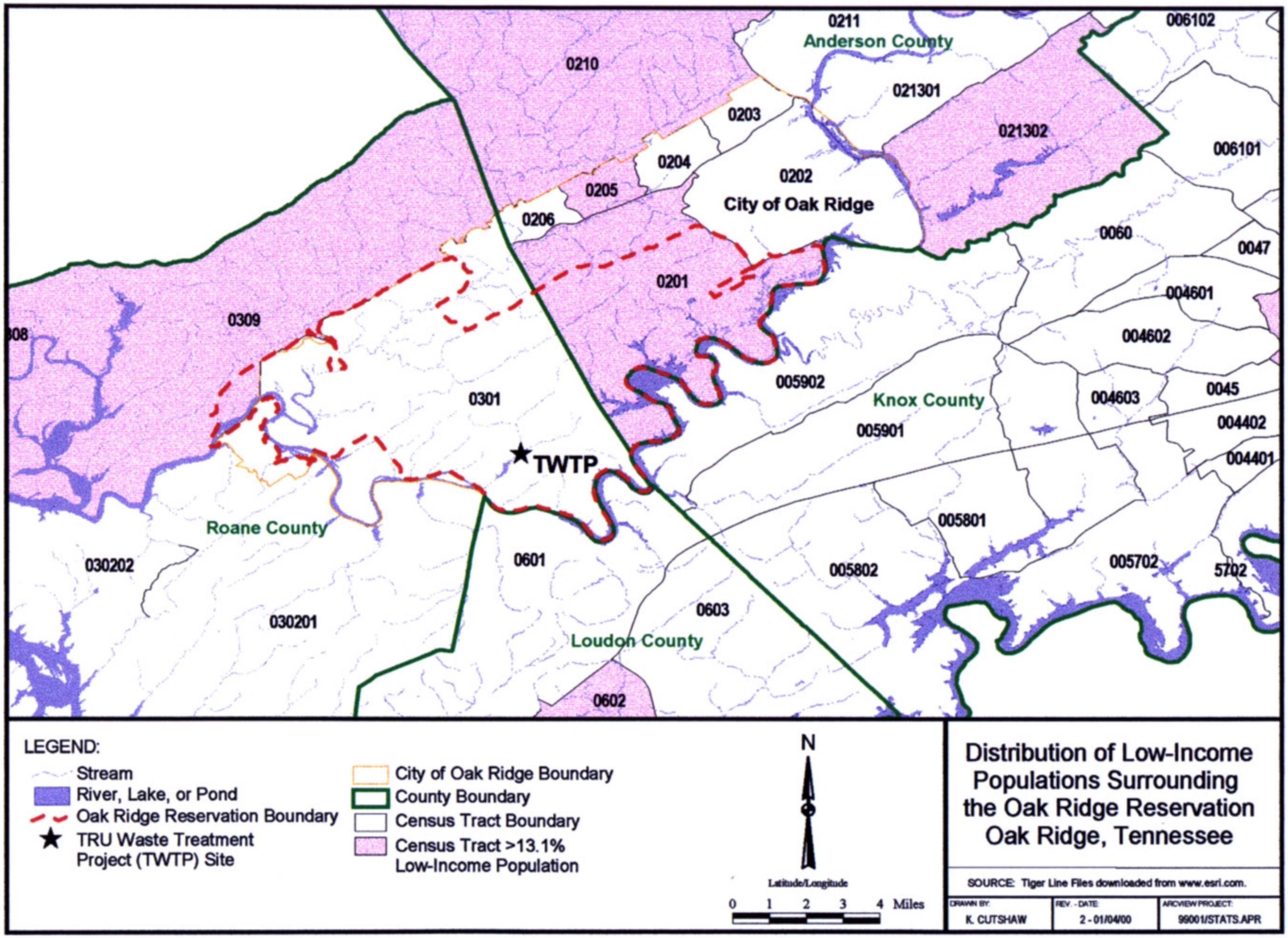


Figure 3-23. Census tracts with a low-income population greater than the national average of 13.1%.

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